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Faculty of Social Sciences
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MASTER THESIS

Poor health and early exit from labour force: an analysis using data from Survey of Health, Ageing and Retirement in Europe

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Declaration of Authorship

The author hereby declares that he compiled this thesis independently, using only the listed resources and literature.

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Prague, May 12, 2011

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Abstract

Health is considered to be one the main determinants of retirement decision. A majority of empirical studies implements health using self-perceived health status measures. According to the justification hypothesis such a method may introduce a bias into estimation, and moreover, this bias may vary from country to country. The aim of this thesis is to make use of a dataset rich in objective measures of health from the second wave of Survey of Health, Ageing and Retirement in Europe and to put side by side the estimates based on subjective measures as well as IV estimates using more objective variables and thereby to assess the magnitude of possible endogeneity and measurement error. It applies these identification methods on the model of early exit from labour force and discusses gender differences and specifics of given EU countries.

JEL Classification	I10, J26, C35, C42
Keywords	health, labour supply, retirement, measurement error

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Abstrakt

Zdravotní stav je považován za jednu z hlavních determinant rozhodování o odchodu do důchodu. Většina současné literatury implementuje zdraví do empirických modelů skrze proměnné, které jsou založeny na informaci o subjektivním hodnocení zdraví mezi respondenty výberových šetření. Takovéto měření zdraví však může vnést zkreslení do výsledků těchto studií, pokud je hodnocení závislé na sociálním a ekonomickém postavení dotazovaných. Práce srovnává tento typ odhadů s odhady využívajícími širokou škálu informací o zdraví z projektu Survey of Health, Ageing and Retirement in Europe. Pro odhad modelu předčasného odchodu do důchodu je aplikováno několik ekonometrických a vícerozměrných statistických metod.

Klasifikace JEL	I10, J26, C35, C42
Klíčová slova	zdraví, nabídka práce, odchod do důchodu, chyba měření

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Contents

List of Tables

List of Figures

Master Thesis Proposal

Author	Bc. Václav Hausenblas
Supervisor	Ing. Filip Pertold, M.A., Ph.D.
Proposed topic	Poor health and early exit from labour force: an analysis using data from Survey of Health, Ageing and Retirement in Europe

Topic characteristics The aim of the thesis is to explore an advanced topic of labour economics – retirement. Author uses a cross-national panel micro-data of SHARE-PROJECT, a survey on health, ageing and retirement in Europe, and analyses the main institutional, cultural and time-specific determinants of decision making of elderly whether to stay employed or to retire with primary focus on the Czech Republic. A particular attention is paid to experience of communism and consequent transition period spread among older workers and its effect on their employment status. Further topics are to be discussed as well, gender differences and regional diversity being some of them. A careful use of econometric methods applied on micro-data is also a very important aspect of the work.

Hypotheses

1. Determinants and their importance differ for men and women.

    In terms of labour participation and employment status, female workers empirically diverge from male workers. Their higher elasticity of labour supply should have an effect on their decision of retirement. Statistically significant gap in age of spouses is also an important phenomenon to be taken into account.

2. Regional differences are expected to emerge in behaviour of elderly.

The patterns of employment in various regions are very closely related to its industrial structure, environmental qualities and infrastructure. Living conditions and employment opportunities are heterogeneous in Czech Republic with two counterparts, urban and rural environment.

3. Experience of communist regime and its restrictions on labour market together with subsequent transition process had both significant effect on employment of elderly.

   The velvet revolution can be perceived as a kind of natural experiment in social sciences. The effect of such a huge change in institutions will be tested. Also a panel structure of available data allows to compare patterns in post-communist countries with those of other European countries.

Methodology An econometric approach on micro-data will be applied to test hypothesis coming from theoretical models and economic intuition. A lot of interest will be focused on proper treatment of observation with missing values – a common obstacle of given kind of data. Various method have to applied for sub-sampling of the data to get appropriate treatment and control group of respondents. The challenging job is to control for all important observables in the models, appropriate explanation of possible weaknesses and careful interpretation of results and implication. The test the direction of causality should be a task for instrumental variable approach.

Outline

1. Introduction
2. Review of literature
3. Theoretical models and declaration of hypothesis
4. Description and analysis of available data
5. Results of regressions
6. Conclusion

Core bibliography

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Author

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Chapter 1

Introduction

Health is considered to be one the main determinats of retirement decisions, or in more general terms – exit from labour force – even though theoretical models do not give an unambigous answer to the question of eventual effect on employment since health can potentially affect both utility from leisure or consumption (a positive effect) and productivity (a negative effect). Unfortunately, even in empirical framework, identification and evaluation of the effect on worker's decision-making is a non-trivial task. Majority of empirical studies on labour force supply decisions implement health using self-perceived health status measures, information that is easily obtainable in labour force surveys. A so-called justification hypothesis suggests, however, that such a method may introduce endogeneity bias into the estimation. According to justification hypothesis people tend to exaggerate bad health as a reason of their retirement and thus self-evaluated health becomes endogenous to employment status in any kind of retirement model. This bias means that evaluation of health is not independent of other factors such as job satisfaction and conditions, wages or various other social status characteristics that correlate with employment status. Models using such measures are supposed to overestimate the impact that bad health has on employment status. The evidence of systematic measurement error was provided by authors of studies using data from surveys in United States.

Variables derived from self-assessed scale measures of respondent's health status may also suffer from a considerable random measurement error due to linguistic and cultural differences as well as questionnaire design of a given survey. The aim of this study is to put side by side estimates based on such subjective measures as well as those using more objective measures and to assess the magnitude of possible endogeneity and measurement error. It applies various econometric methods to identify a model of early exit from labour force using data from the second wave of the Survey of Health Ageing and Retirement in Europe (SHARE).

Early exit from labour force caused by health difficulties represents an important link between social security, social insurance and health care systems. Evaluating the weight of this linkage is a necessary step to consistently estimate the effect of various health care policies. Further, both health care and social insurance programs are now in the center of attention in many European countries (the Czech Republic being one of them) due to an urgent need of reforms and austerity measures within overall fiscal consolidation under pressure of adverse demographic changes. Another aspect is, for instance, an issue of credit risk. A labour market where workers easily lose income (or at least part of it) as a consequence of random health shocks might produce a higher number of insolvent households.

Comparison of subjective and objective measures has an important psychological point. A social pressure on people without job which makes them justify their decision and exaggerate their health condition refers to a serious social imbalances and insufficient opportunities to realize social and economic potential of such individuals.

In both theoretical and empirical studies a controversy whether health or economic factors (compensations, incentives, savings and other assets) are the main drivers of the decision persists. While on the theoretical level such controversy is linked to already mentioned ambiguity of hypothetical health effect, in empirical research it stems from aforementioned identification issues. Ignoring these issues leads to biased predictions of retirement models and wrong policy implications.

This study contributes on several levels. Previous analysis of the topic was applied to the data from surveys restricted on a few developed countries and it mostly limited its attention on male workers. We employ a new dataset covering, besides the old EU members, some additional countries, namely the Czech Republic, Poland and Ireland.[1] The uniform design of the survey applied in all these countries allows to maintain a high level of consistency of separate models for different subgroups and thus makes it easier to compare the results.

[1]Up to now data for the Czech Republic such as Household Budget Survey, EU-SILC or Labour Force Survey conducted by the Czech Statistical Office were rather weak in terms of health observations.

This comparison is important for evaluating social insurance and social security schemes as well as labour market conditions. Furthermore, the dataset includes both male and female respondents which further increase its information value.

The thesis also applies new methodological elements such as principal component analysis of health to address the issue of collinearity (due to a/ low ratio of sample size vs. number of variables, b/ nature of health measures) and multidimensionality. Another original element is using seemingly unrelated regression method to test the endogeneity of subjective health variables. Previous works were aimed at controlling for the bias in retirement modeling while this study also addresses the quality of potential bias itself, analyzes the differences across various countries and tries to explain them.

The structure of the thesis is as follows: Part I surveys the existing theoretical and empirical research on retirement and retirement modelling. The description of theoretical background given in Chapter 2 is followed by survey of empirical implementation alternatives (Chapter 3) and related econometric issues (Chapter 4). In the end of this part, three hypotheses, a basic research questions for the empirical research, are formulated.

Part II provides assumptions and specification of empirical models used to test declared hypotheses in Chapter 6. Data used for the analysis are presented in Chapter 7 while Chapter 8 concerns with multi-dimensional nature of health. Chapter 9 presents and discusses the results of our research and the thesis concludes in Chapter 10.

Tables of detailed reports from regression and other relevant information can be found in Appendix D–E.

Part I

Survey of literature

Chapter 2

Models of retirement in economic theory

While it seems to be appropriate to begin with a definition of retirement there is no sharp definition of this phenomenon (Gustman & Steinmeier 2007). Simple definitions such as that retirement is an event that occurs when an individual stops working completely are not taking into account the complexness of the process when some people may change their job for an easier one or they just reduce the working hours and other gradual or partial pathways to retirement. The definition that would serve the purpose of analyzing relationship between health and retirement would be the most general one. The rest of the study thus pools all kinds of evidence of leaving the market such as (early) retirement, disability or unemployment in old age and any other pathways to retirement into a single definition. For this reason the term *(early) exit from labour force* often takes the place of the term *(early) retirement* further on in the text.

In the early economic literature retirement was mostly regarded as involuntary. The reasoning behind this thought was that workers retired either because of health limitations or when employers dismissed them from their jobs. Such an approach was not naive but originated in times of rather underdeveloped welfare state and its social security programs. In these times wide family households and private savings as a resource for elderly were of higher importance. Later research and further social and economic development introduced a different view where retirement decisions have been considered as rather voluntary actions. The timing of the decision would correspond to the moment when utility from leisure overweights the compensations from work.

Current research on the topic is, in general, divided into two streams of thought – a static single-period *wage-leisure models* and *life-cycle models* – according to the extent how far are individuals assumed to be forward-looking. A comprehensive general survey of economic modeling of retirement can be found in Leonesio (1996).

The static approach models a situation where individuals find themselves "eligible for retirement" and weight the costs and the benefits of both alternatives: to stay in the labour force or to leave to retirement. In addition to their wages and possible pension benefits, individuals take into account various other factors: current health status, family conditions or their workplace characteristics and situation on labour markets.[1] This is a traditional, easily applicable but still popular approach in labour economics (Quinn 1977; Gordon & Blinder 1980).

In the second and younger approach, a life-cycle model based on the *permanent income hypotheses* allowed to integrate the expectations and dynamic patterns of behaviour. These life-cycle economic models originally assumed workers to be perfectly informed, smoothing their life-time income and fully anticipating the changes in benefits and pensions and hence being able to maximize their *life-cycle utility function* within their *life-cycle budget constraint*. An example of such model may be found in Burkhauser (1979). This element of anticipation of large number of variables (e.g. future health status) is however in huge contrast with modern concept of uncertainty among economic agents and with the fact that social security systems and private pension plans are of rather complex nature and change over time (with frequent policy reforms). Subject to uncertainty is also a wide set of random events such as health status shocks, adverse situation on labour market and other unanticipated macro and micro events. This is why the life-cycle approach of modern labour economics moved to the assumption of *rational expectations*.

Some literature also suggests that economists disregard non-maximizing behaviour of individuals "who do not fully understand the incentives from their retirement programs".[2] Some of them may plan well, but others do not plan at all.

Further research in labour economics brought so-called *dynamic structural models* to explain the timing of participation decisions as a consequence of changes in labour market conditions or certain personal characteristics. It al-

[1]Recent financial crises and following economic recession had affected labour markets and increased flows of labour force especially between unemployment and inactivity. Adverse conditions on the market caused many people to retire earlier.

[2]See pp. 18 in Gustman & Steinmeier (2007).

lows some variables to vary over time and also to control for endogeneity of some of the key explaining variables. These improvements allowed to follow complex causal relationships between economic policies and effects on labour markets. This development was facilitated, to a considerable extent, by the availability of new rich datasets, improvements in empirical methods and growing computational capacity. Perfect examples of such modeling applied to (early) retirement analysis are in Gustman & Steinmeier (2005; 1985) or any other paper by the same authors.

Health changes are rather random events and thus bring considerable uncertainty into the decision-making process of an individual. As such, they can hardly be forecast during the life-cycle and incorporated into any plans. But, on the other hand, worsening of health with age should not surprise anyone. The rest of this thesis is thus following the traditional approach based on static wage-leisure theoretical framework. Optimization and rationality is constrained to a single moment or a short-term horizon with imperfect knowledge covering only information on recent and past events and the near future.

Chapter 3

Health and retirement in empirical models

An individual finds himself on a budget constraint given by compensations and old-age pension benefits. The budget curve of an older worker consist of lines AB and BC shown in the left part of Figure 3.1. In the point C, individual receives only old-age benefits. The line BC represents income from partial retirement (usually earnings tested) while the slope of AB is given by compensations from work.

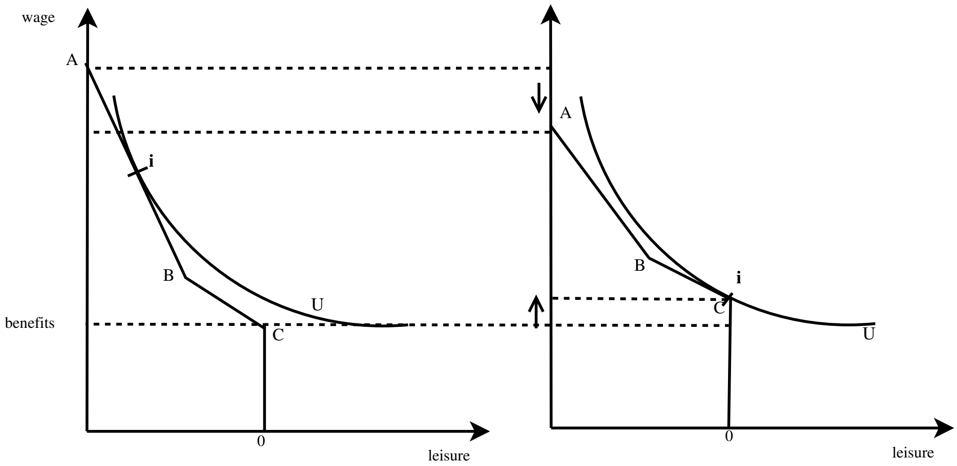
His utility U, on the other hand, is a function of consumption and leisure and is dependent on many attributes such as health status, family conditions etc.

A situation where an individual decides to stay in the labour force is illustrated in the left part of the figure. A change in wage (as an outcome of adverse shocks on labour markets or health status change) or a change in benefits (a reward for not leaving the market early) or both may lead to retirement as illustrated on the right side. Any change in preferences and implied change in his utility function may unfold the *indifference curve* and result in a similar effect.

The probability that the individual i, eligible for social security (old-age, disability or any similar) benefits, is employed (works at least L hours) is a function of economic variables (wage/pension replacement ratio, savings and other assets), job satisfaction, health status and various other social-background factors (such as marital status, family conditions, education):

$$P(l_i > L | w_i, h_i, Z_i) = f(L, w_i, h_i, Z_i)$$

Figure 3.1: Wage-leisure labour supply framework



where L is a constant given by regulatory framework of social security system, w is wage, h a health status score(s) (let high value indicates worse health) and Z is a set of other characteristics as indicated. The subject of empirical research

$$\frac{\partial f(L, w, h, Z)}{\partial h}$$

is a complex formula and may in theory take both negative and positive values as health has an impact on utility of leisure and consumption as well as on productivity and wage. Bad health can increase the individual's need of consumption and demand for drugs or medical treatment. Higher consumption require higher income which leads to higher participation. Health may also reduce a utility from leisure and thus increase the probability of participation (Deschryvere 2004).

A negative marginal effect, on the other hand, may be expected as bad health h is negatively correlated with productivity and therefore wage w. It has a negative impact on utility of consumption (of other than medical goods) and thus decreases the need of a higher income. In a life-cycle framework bad health also reduces life expectancy and hence the time available for consumption of savings and other assets.

The evidence that health status is one of the most significant determinants of retirement decision is supported by a rather large amount of empirical literature (Bazzoli 1985; Hausman & Wise 1985; Sammartino 1987). To list some of the recent works Kalwij & Vermeulen (2008), Meijer *et al.* (2008) use the data from the first wave of SHARE and confirm that European workers' labour supply is significantly negatively affected by poor health.

Most of the studies limits the research on a single economy due to availability of appropriate data. Jiménez-Martín *et al.* (1999) however studied the effect of health on joint decisions of couples using European Community Household Panel data. Especially male health was proved to be relevant to the decision of both an individual and a whole couple. The more the household budget is dependent on man's income the more the effect is significant. On the opposite, woman's health was not such a significant covariate. Pamela Loprest & Sandell (1995) found that bad health has greater effect on labour force participation for men and single women than for married women. Their analysis, however, was based on estimating reduced-form logit model of labour supply for sub-samples of men and women separately and consequent comparison of estimated coefficients which modern statistics do not consider as a convincing method to test hypotheses of significant deviations in gender behavioral patterns. They also did not deal with multidimensionality of health limitation measures.

As stated above, besides his preferences worker's, health also affects productivity and hence employers' demand for labour of that worker. Some authors claim that the importance of health on retirement is correlated with the level of development of given economy. They found their argument on studies of *Retirement History Study,* a panel data collected from 1969 to 1979, and *Health and Retirement Study,* a new panel data collected from 1992 in the US. This would imply that health is more important determinant in less developed or in industrial countries where any health limitations represent a serious barrier to work in major parts of its labour market. On the other hand, well-developed countries are characterized by the generosity of social security system which may compensate this effect.

Chapter 4

Health and retirement – identification issues

4.1 Endogeneity and measurement error in self-reported health variables

In order to quantify accurately the effects of various factors determining retirement decisions economists should carefully allow for interactions of explanatory variables. The literature (Bound (1989), Bound *et al.* (1998) or Dwyer & Mitchell (1998)) names two channels that can bring endogeneity issue into retirement models with health as an explanatory variable, both of them being relevant to using popular self-reported measures of general health:

1. Random measurement error: commonly used measures of worker's health based on self-reported rankings are supposed to be subject of considerable measurement error. The data are usually focused on economic variables it is rather rare, though, to have some better information on health at one's disposal. The choice of appropriate measures is thus very limited.

2. Reporting bias: First, subjective health measures may not be independent of irrelevant factors or current state of an individual. They are subjects to individual-specific reporting and as such are not optimal for use in an empirical analysis on inter-personal level. Perception of health can be affected by social and cultural institutions that are specific to given country or social group. Second, response of an individual is not independent of his current state, survey conditions as well as a specific wording of a question. Third, the respondent may have many reasons to exaggerate or undervalue his or her health status. Empirical retirement modeling accounts for at least two of them:

disability benefits eligibility motivation and justification bias. Justification hypothesis claims that some people exaggerate bad health status to justify their retirement while other factors were the true determinants of their decision. In other words, they blame their (early) retirement on health even though they retired for some other reasons. Such a bias causes systematic underestimation of health status as a determinant of labour force participation and directly rules out pooling observations for both active and retired workers within a single model.

Many empirical studies like those by Rust (1994); Blundell *et al.* (2002) use a single self-assessed health measure to control for health in their models and thus either ignore the endogeneity problem or argue that using self-assessed health variable avoids other problems that come with more complex methods. Also Galuscak (2001) analyzes retirement decisions of Czech male workers and the effect of introduction of earnings test on participation of pensioners. Using data from Labour Force Survey, self-perceived poor health proved to be a significant negative determinant of the exit decision.

There are however some arguments against using more objective measures as well. Not only it is hard to cover all the objective aspects without omitting some specific but important variable, but it is also very difficult to summarize all the information into one or a few numbers. Kalwij & Vermeulen (2008) use the term "multidimensional nature of health status". While summarisation of many variables decreases the explanatory power of such model, including too many variables in a model makes any interpretation of results less straightforward and clear. For this reason some economists suggested using self-reported health status measures instead (Bound 1989). This method allows to transfer the problem of reducing dimensions to respondents.

One of the most elaborated attempts to implement health into economic models was done by Meijer *et al.* (2008). Unlike other papers, this one deals with complex multidimensional nature of health by using multivariate factor analysis. They employ 24 various health indicators as dependent variables and objective measures such as grip strength as exogenous explanatory variables. Maximum handgrip strength is used as a cross-national scaling tool which "helps to overcome the measurement issues related to biases that arise from subjectivity of self-reported health and health conditions due to cultural differences across and within countries, differential physician contacts."[1] They

[1]See p. 7 in Meijer *et al.* (2008).

also advert to the fact that maximum grip strength is a well-established tool to predict future health conditions and mortality.

Most of the points mentioned above introduce the reasons to approach self-reported health status in retirement models as an endogenous variable once the research has sufficient amount of objective information to control for endogeneity. From this perspective, a single linear regressions explaining economic and social behaviour of elderly cannot estimate the effects of different determinants correctly. Endogeneity and multicollinearity induces bias in

- statistical and economical effect of health variable(s)
- statistical and economical effect of other variables that are correlated with health (even if we have a perfect measure of health status)

4.2 Correcting for bias and other identification issues

Some papers were aimed at addressing and resolving the controversy of objective versus subjective measures in econometric models. The main problem with comparing methods of these papers lies in the fact that their methodology was seriously dependent on specific properties and limitations of data in use.

Bound (1989) provided a very general model of labour force participation of elderly which showed potential pros and cons of those two most common alternative methods and served as theoretical basis for later research. It uses one objective variable, observed mortality – a variable constructed from large longitudinal survey data, as an instrument and proxy for health. Using data from the Retirement and Health Survey (RHS from now on) based on a sample of men aged from 58 to 63 and conducted during 1969–1978 in the United States he shows that results may differ significantly according to chosen proxy for health and method of identification.

Author defines labour-force participation, self-reported health and mortality equations:

$$lf^* = \lambda_1\eta + \beta_1 w + \varepsilon_1 \tag{4.1}$$

$$h = \lambda_2\eta + \beta_2 w + \varepsilon_2 \tag{4.2}$$

$$d^* = \lambda_3 \nu + \varepsilon_3 \tag{4.3}$$

$$w = \lambda_4 \eta + \varepsilon_4 \tag{4.4}$$

$$\eta^* = \nu + \mu \tag{4.5}$$

where w stands for compensation, h for self-reported health status and d^* for mortality. A true health stock η decomposes into ν – the part of the health that affects both productivity and mortality – and μ – the part of the health that affects capacity to work only – such that ν and μ are uncorrelated with each other. An asterisk indicates an unobserved, latent, variable with (lf, d) or without (η) an observed dummy counterpart.

Further assumptions are taken: η is uncorrelated with $\varepsilon_1, \varepsilon_2, \varepsilon_4$ and ν with ε_3 and thus η is not correlated with ε_3. On the other hand, due to endogeneity in unobservables (justification bias), ε_1 is expected to be correlated with ε_2.

As follows from equations and corresponding assumptions, both h and d are imperfect proxies for η as they both introduce a bias in estimating (4.1). Variable h is not independent on wages and the more objective variable d is an incomplete measure of health which also makes it an inappropriate instrument to h. The system of equations is moreover under-identified without assuming adequate arbitrary exclusion restrictions.

Results indicate that using mortality to approximate health in a model of labour participation "exaggerates the impact of economic factors and underestimates the impact of health by substantial margins"[2] as it ignores unobserved part of health. On the contrary, using mortality to instrument self-reported measure, a procedure initially proposed by Stern (1989), exaggerates the impact of health and underestimates the impact of economic variables, namely compensations.

The author concludes that the method of using objective measure d to instrument self-reported measures only multiplies the bias inherent to self-reported measures and he recommends using the naive endogenous variable alone instead. Moreover, he argues, endogeneity factors within self-reported variables may cancel out each other. To improve the credibility of estimates with both instrumental variable and proxy methods one would have to bring

[2]See p. 131 in Bound (1989).

additional objective information on health or on reliability of mortality as a proxy for health. This would both help with the identification of the model and to get rid of the bias in estimates. Due to lack of data, the study has to simulate the magnitude of simultaneity and thus contributes mainly on theoretical level.

Dwyer & Mitchell (1998) made another attempt to address justification bias and measurement error in health variables, this time using Health and Retirement Study – the first data abundant in objective information on worker's health stock. They approach justification bias as a significant deviation of OLS and IV estimates. They also test for measurement error in both subjective and more objective variables using instruments such as parents' health, age, number of visits to a doctor or number of children. Their model has a form of these structural equations:

$$R = \beta_1 w + \lambda_1 \eta * + \gamma_1 Z_1 + \varepsilon_1 \tag{4.6}$$

$$w = \lambda_2 \eta * + \gamma_2 Z_2 + \varepsilon_2 \tag{4.7}$$

$$H = \lambda_3 \eta * + \varepsilon_3 \tag{4.8}$$

The reasoning behind justification hypotheses in their concept is that "w is correlated with the resulting systematic measurement error ε_3 because low earners will prefer retirement leisure and use poor health to justify their early withdrawal."[3] They expect the effect of self-reported health on early retirement to decrease after instrumenting and to increase for the case of objective health variables.

The authors found only little evidence of justification bias. The only variable contaminated was a dummy indicator of health limitation to do a paid job.[4] Also Hausman-Wu test did not bring any evidence of measurement error in either objective or subjective health indicators.

It is however inappropriate to apply the results of findings based on data

[3]See pp. 177 in Dwyer & Mitchell (1998).

[4]This variable is of the same nature as variable LIMITATION used in the empirical part of this thesis. See chapter 7 for description of the dataset.

from the United States to the European countries. It is the aim of this theses to make a counterpart to this research on data from the EU countries.

4.3 Testing for endogeneity

Kalwij & Vermeulen (2008) accent the multidimensional nature of health and address one weakness of instrumental variable approach. They argue that some objective health conditions may have a direct effect on labour force participation besides the indirect one through an self-reported overall health indicator which makes the instrumental variable method inappropriate.

Endogeneity of self-reported health is, in a framework of this omitted variable approach, assumed to stem from explanatory power of such a variable on the top of the information in a set of more objective measures. Variance in labour force participation is thus significantly explained by self-reported variable even when controlled for all observable objective measures.

Two conditions should be met to justify such a model:

1. Self-reported health variable is significantly correlated to labour force participation.

2. Self-reported health variable remains a significant regressor even after controlling for full set of objective exogenous regressors.

Their work applied the test on the data from the first wave of SHARE which did not cover the Czech Republic, Poland or Ireland. Furthermore, the authors restricted the sample on people below normal statutory retirement age in belief that only these people need to justify their retirement decisions and bias their responses.

There are however serious drawbacks with this test. First, the paper ignores the differences in reporting patterns among the countries (presented later in Chapter 7). It constructs a dummy variable signaling bad health so that people who responded by a lower grade then "good" (on a scale of "excellent", "very good", "good", "bad" and "poor") were classified as "bad" and all others as "good". There are however significant deviations from normal distribution in the original self-reported variable and using such constructed categorical variable derived from responses rules out any kind of comparability separate tests on data from different countries as it ignores cultural and language deviations in these subsamples.

Second and the main problem of the presented test is its ambiguity. The joint significance of both (sets) of variables may have two explanations: 1) endogeneity (by omitted variable) and/or 2) invalid instrumental variables. Let me rewrite the model used for the test more formally in

$$lf_i = \alpha h_i + Z_i'\gamma^1 + X_i'\beta + \varepsilon_i \tag{4.9}$$

$$lf_i = \alpha h_i + X_i'\beta + \varepsilon_i^1 \tag{4.10}$$

where for an individual i lf_i is the probatility of participation, h_i is a self-reported measure, Z_i is a vector of objective measures and X_i a vector of other socio-economic variables and suppose that

$$h_i = Z_i'\gamma^2 + \varepsilon_i^2 \tag{4.11}$$

A rejection of Wald test of joint significance ($\gamma^1 \neq 0, \beta \neq 0$) indicates one of these situations: 1) $cov(\varepsilon^1, \varepsilon^2) \neq 0$ but also 2) $cov(Z, \varepsilon^1) \neq 0$ or both. If we run the test to investigate primarily the first case, we observe a statistics on both of the issues in a single number. The instrumental variable validity is based on the assumption that a valide instrument a) does strongly correlate with endogenous variable and b) does not have a direct effect (other than through an endogenous variable) on the explained outcome variable (labor-force participation). In a framework of OLS, this direct effect is tested by Sargan test of correlation between instruments (in a first-stage regression) and errors in original reduced equation (the second-stage equation with original endogenous variable) (Wooldridge 2010).

Their results suggest that in some countries, self-reported measure does a fair job in explaining participation without evidence of bias. And that on the other hand, in Denmark, the Netherlands or Sweden, using only self-reported variable leads to biased estimates. We test this heterogeneity findings using more advanced econometric and statistical methods. The paper also does not give any solution to retirement models that aim at evaluating the effect of poor health on retirement.

Considerably less evidence was brought to the topic of gender differences and its impact on retirement behaviour. Ettner (1997) suggest that being out of the labour force may be less socially stigmatizing for women than for men and so there can be expected less reporting bias among women.

4.4 Further considerations

4.4.1 Overall health versus limitations to do a paid work

Since health in general is so difficult to be measured we may not be interested in overall health of an individual and we'd rather like to focus on the part of his health that is relevant to labour market participation. Subjective measures may perfectly describe overall health but the relation between overall health and disability may be very complex and may depend on specific occupation characteristics. Similarly, a single composite index of health may not be correlated with labour force participation. To give an example, a different elasticity to health changes of a mine-worker to that of an office clerk can be expected. A solution to this would be to ask the respondents on their limitations to do a paid job. It is however even more likely that reporting and justification bias occurs in such a capacity-to-work self-reported measure than in an overall health measure as it demands more, and often unobserved, information.

4.4.2 Reverse causality

One of the main identification issues in applied microeconometrics is a problem of *reverse causality* (Cameron & Trivedi 2005). A hypothetical causal relationship (or at least its direction) is hard to be empirically proved or rejected by simple econometric methods due to a non-experimental nature of most of the economic data. It is usually solved by an arbitrary assumption by definition (supported by another theory or empirical evidence) or by using structural econometric analysis of panel data. Also using lagged values or instrumental variables are the very popular methods to control for endogeneity.

Regarding the topic of this thesis, a threat of reverse causality problem may arise from the fact that retirement itself may also affect health. Behncke (2009) uses non-parametric matching methods to identify causal effects of retirement on health using data from English Longitudinal Study of Ageing (ELSA). He found out that retirement increase the risk of developing a cardiovascular disease and being diagnosed with cancer. Similar findings may be found in Bound & Waidmann (2007); Neuman (2004). On the other hand (Mojon-Azzi *et al.* 2007) do not find any evidence of negative retirement effect on health. On the other opposite, they find the evidence of less frequency of depression and anxiety among Swiss after retiring.

Chapter 5

Conclusion and formulation of hypotheses

Estimating effects of health on retirement is a complex and difficult task. Empirical research in this area is very limited by low availablity of appropriate data and even its perfect availability would not prevent identification problems. Multidimensional nature of health measured by objective variables and systematic and random measurement error problems connected to self-reported measures as well as reverse causality are the main barriers to estimate the empirical models of labour supply decision in advanced age. Availability of data also limited the research on the US economy and a few EU economies and prevented from analyzing the regional specifics in terms of differences in effects on employment or in reporting patterns.

Although the theory does not give unequivocal answer to the question of impact of health on employment, empirical evidence from major part of research concludes that bad health negatively affect labour force participation.

Hypothesis 1: Bad health has a negative marginal effect on probability of being employed.

Findings of several empirical studies suggest that labour supply of women is less sensitive to health problems than that of men. This does not correspond to a well-known empirical evidence that elasticity of labour supply of women is in general higher compared to that of male workers. It may, however, be connected with womens' lower labour force participation. While most of the surveys concerns of male workers, this topic is yet to be elaborated.

Hypothesis 2: Labour force particiaption of female workers is less sensitive to deteriorated health than those of male workers.

The studies on data from Health and Retirement Study in United States brought the evidence of justification bias that makes self-reported health measures endogenous to employment status. Similar research on data collected in Europe did not present any strong support of these findings. It was hypothetised however that these reporting patterns may be country-specific and may be limited to workers only of a male gender.

Hypothesis 3 (Justification hypothesis): Early inactive people tend to exaggerate their health problems to justify their early exit from labour force.

Part II

Empirical analysis

Chapter 6

Specifications and assumptions of the model

The following part of the text presents an empirical model of early exit from labour force designed for the purpose of estimating the effect of bad health on labour force participation decisions among elderly. The analysis is divided into four consequent steps. First, a naive model where self-perceived health is treated as exogenous variable is specified and identified. This method provides baseline estimates for further discussion since most of the empirical research contents with such treatment of health. In the second step, we approach the set of objective information about health using Principal components analysis method to get objective regressors used later for tests of exogeneity of health and for instrumental variable estimation . In the third step, we formulate a test to identify the endogeneity due to the systematic reporting bias. It is based on testing the simultaneity of reporting and labour force participation equations. Based on the results in this test, estimation using instrumental variables is applied in the fourth step.

A significant part of the text is devoted to description of data in use, relevant summary statistics and specific data handling and preparation.

6.1 Health as an exogenous variable – a naive model

In the first place a simple model of probability of being active is specified as follows

$$p_i^* = \alpha h_i + X_i' \beta + \varepsilon_i$$

$$lf = \begin{cases} 1 & if \;\; p^* > 0 \\ 0 & if \;\; p^* \leq 0 \end{cases} \tag{6.1}$$

Instead of a latent probability p_i^* of being employed a dummy variable lf_i of i's worker status is actually observed and thus an ordinary probit estimator is applied. Labour force participation status is represented by an indicator of having a paid job while the baseline sample consists of retirees, unemployed and disabled. Such a pooling of these three categories is consistent with major part of related literature and empirical studies since it allows to consider more alternative exit routes than a sole institution of early retirement.

Three alternative variables (implying three separate estimations) of self-perceived health, LIMITATION (dummy), HEALTH-US and HEALTH10, described in Chapter 7 were used as proxy for respondent's health h in separate estimations (producing alternative estimates).

The vector X_i of control variables on demographic characteristics consists of: the number of children and a set of dummy variables indicating years of age,[1] marital status, educational background, working status of a spouse, job in a public sector, self-employmen indicator, place of living (rural, town or city).

To test the **Hypothesis 1** claiming negative marginal effects of health on probability of being employed a significance on 5% level of z-score statistics is used. Z-score is the ratio of the marginal effects to the standard error of the respective estimate and follows the standard normal distribution.

To test the **Hypothesis 2** (that employment of women is less sensitive to poor health) a Chow test is proceeded through nested model regression:

$$p_i^* = \alpha_1 h_i + \alpha_2 (h_i * female_i) + female + X_i' \beta + \varepsilon_i$$

where $female$ is a categorical variable indicating female gender. The null hypothesis that α is constant for males and females is rejected if z-score statis-

[1] The social security systems in EU vary in regular retirement age. The sample was restricted according the rules in given country . In the Czech Republic for example the regular retirement age is systematically increasing since 1996. Women are moreover let to retire one year earlier for every child up to four. A precise rules of retirement age in Czech Republic and other countries that were taken into account in this thesis are shortly reviewed in Appendix C.

tics (following standard normal distribution) for α_2 is significant on level of 5 %. This method assumes identical distribution of errors for both genders.

6.2 Health as an endogenous variable

6.2.1 Testing for endogeneity – seemingly unrelated regression equations method

In this section, we present a model which is a simplified version of a model presented in 4.2 and adopted from Bound (1989). Following system of equations consists of equation of labour force participation, equation of reporting health (resp. limits to do a paid work) and equation of a latent health stock. The simplification lies in omitting equation on wage compensation.[2]

$$p^* = \lambda_1 \eta^* + \beta_1 X_1 + \varepsilon_1 \tag{6.2}$$

$$h = \lambda_2 \eta^* + \beta_2 X_2 + \varepsilon_2 \tag{6.3}$$

$$\eta^* = \gamma C + \nu \tag{6.4}$$

$$lf = \begin{cases} 1 & if \;\; p^* > 0 \\ 0 & if \;\; p^* \leq 0 \end{cases} \tag{6.5}$$

p^* – probability of labour force participation (we observe only the status lf)

h – self-reported measure of health (LIMITATION, HEALTH-US or HEALTH10)

η^* – vector of latent variables representing health stock

X – vector of socio-demographic characteristics

C – components of health

$\varepsilon_1, \varepsilon_2, \varepsilon_3$ resp. υ are disturbances, resp. vector of disturbances

$cov(\varepsilon_1, \varepsilon_2) = \rho_1$ and $cov(\varepsilon_1, \varepsilon_3) = \rho_2$

This time we do not focus on estimated coefficients and standard errors but instead on correlation among equations (simultaneity). Hypothetically, there is a common information in residuals of equations (6.6) and (6.7). In other words,

[2]This weakness stems from the lack of the data described in Chapter 7. A single wave of the survey allows to observe wages only for employed respondents.

an unexplained variance in labour force participation is present in unobserved determinants of reporting patterns.

Equation (6.4) corresponds to an assumption that components of health can be approximated by objective observable indicators. There are two options how to implement such an assumption. First, to use a full set of objective indicators in database as a proxy for health. A bunch of approximately 80 indicators on health conditions, ADL and IADL, maximum grip strength and many others can be used as explaining variables. Including such a number of regressors may however entail violation of assumptions of the regression technique, namely it can bring a multicollinearity issue.

Another option is to reduce the number of regressors and to use only the most of the variance in the original full set. A principal component analysis presented in 8.1 is the most natural candidate to do this job. With its help we can obtain and make use of unique orthogonal regressors.

Maximum likelihood estimation

We deal with endogenous binary (resp. discreet limited) response variable LIMITATION (resp. HEALTH-US and HEALTH10) and one binary outcome variable and thus a two-stage least-square estimation (2SLS) is not an adequate technique to identify the model (Wooldridge 2010). In correspondence with the previous literature we can use the method of bivariate probit model which assumes disturbances to follow a jointly normal distribution.

$$\begin{pmatrix} \varepsilon_1 \\ \varepsilon_i \end{pmatrix} |X \sim N \left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & \rho_i \\ \rho_i & 1 \end{pmatrix} \right] \quad i = 2, 3$$

Testing Hypothesis 3

After estimating a bivariate probit (resp. hybrid probit/ordered probit) of (6.6) and (6.7) we tested for a statistical significance (on 5% level) of $\rho = 0$ constraint of the model.

$$H_0 : \rho = 0$$

$$H_1 : \rho \neq 0$$

Under the null-hypotheses the correlation of disturbances is equal to zero, the two equations are independent and explained variables exogenous (each to other) or all the endogeneity is explained by explanatory variables. Such equations can be estimated separately. Under the alternative hypotheses both equations are related through disturbances and endogeneity occurs. In this case, both equations should be estimated simultaneously. The likelihood-ratio test compares likelihood of the bivariate model with the sum of the logs likelihood for the univariate probit models (Monfardini & Radice 2008; StataCorp 2009).

$$LR = -2\left[l_1 + l_2 - l_{biprobit}\right] \sim \chi^2(1)$$

6.2.2 Instrumental variable estimation

The aim of this section is to provide estimates of the effect of bad health and health limitations to do a paid job free of measurement error. At least two methods are available. First, objective variables may be directly employed in the model. Second, a very popular econometric identification method in economics is a method of instrumental variables. This procedure provides estimates more comparable with the estimates from the original "naive" model but requires the existence of variables which a) are strongly correlated to the endogenous variable and so indirectly influence the outcome variable and b) do not have any direct effect on the outcome variable.[3]

A self-reported variable is to be instrumented with full information on respondent's health represented by principal components discussed later in the text. Similarly to the test of endogeneity in previous section, both the outcome variable and endogenous explaining variables are limited discreet choice or binary choice variables; hence a common two-stage least-squares method (2SLS) is not an option to identify the model and maximum likelihood estimation has to be applied.[4] In case of LIMITATION endogenous variable a bivariate probit was engaged. For both the two remaining alternative variables an ordered probit for first-stage and binary probit for outcome equation were estimated. See p. 478 in Wooldridge (2002) for more details on maximum-likelihood estimators used to estimate the model.

$$p^* = \alpha_1 h + \beta_1 X_1 + \varepsilon_1 \tag{6.6}$$

[3]The topic of valid instruments was elaborated in detail in the section 4.3.

[4]Methods of estimating all models follow Wooldridge (2010).

$$h = \alpha_2 C + \varepsilon_2 \tag{6.7}$$

All the variables keep the same labels as in the previous specification.

To test **Hypothesis 1** in this framework, we use the z-statistics in the same manner as we did with the naive model in 6.1.

Testing **Hypothesis 2** with IV estimates is problematic. There seem to be no solution to test significance of differences between two IV estimtes from two different subsamples. Instead we employ the principal components of health directly into the model and do the same Chow test as well as within the naive model using self-reported measures.

Chapter 7

Data

7.1 Data overview and summary statistics

The data used for the empirical analysis in this thesis come from the second wave of Survey of Health, Ageing and Retirement in Europe (SHARE), a unique cross-European project with a sample of no less then 45 000 people older than 50 years from Germany, Sweden, Netherlands, Spain, Italy, France, Denmark, Greece, Switzerland, Belgium, Czech Republic, Poland and Ireland.[1] A wide set of variables covering health problems "(e.g. self-reported health, health conditions, physical and cognitive functioning, health behaviour, use of health care facilities), biomarkers (e.g. grip strength, body-mass index, peak flow), psychological variables (e.g. psychological health, well-being, life satisfaction), economic variables (current work activity, job characteristics, opportunities to work past retirement age, sources and composition of current income, wealth and consumption, housing, education), and social support variables (e.g. assistance within families, transfers of income and assets, social networks, volunteer activities)"[2] are available to scientists for multidisciplinary analysis.

There are two types of micro units, individuals and households, both linkable through a unique *id* numbers. Up to four members of a single households are interviewed which may be exploited to control for joint decisions of family members and interdependencies in behaviour of spouses.

The sample used to estimate the model of early exit decision was restricted to workers and retirees up to ten years far from the age of regular retirement in given country. An overview of stylized facts about retirement in countries

[1]The SHARE dataset contains also data from Austria but these were dropped due to the low size of its sample.

[2]SHARE-Project (2009)

covered in this study is available in Appendix C. Appendix B gives a full list of variables used for the analysis.

Three variables on respondent's health that will serve as both explanatory and explained variables are of special interest, though. A question asking for evaluation of general health has a form of US-standardized five-rank scaled choice from "excellent", "very good", "good", "bad" and "poor" (HEALTH-US from now on). Another question on general health with scale ranging from 1 to 10 (HEALTH10), where higher value means better health, and a binary-response question on limitations preventing from doing a paid work (LIMITATION) are asked.

Table 7.1 presents summary statistics on probability of being out of the labour force (columns "Exit") and the key health variables for both inactive (and unemployed) and active workers. We can observe significant heterogeneity in surveyed countries both in terms of exit hazard and reporting health. A substantial differences are evident across the countries but also between male and female respondents. Polish and Spanish women have the highest propensity to early exit while on the other side of the spectrum are Swiss and Swedish men. Polish and Czech males feel to be the most unhealthy while Greek and Swiss males feel in average very healthy. Czech males and females are also those who report health limitations to do a paid job most frequently (for detailed statistics on health in the Czech Republic see Table 7.2).

Reporting patterns of HEALTH-US and the sample ditribution of this variable is presented in Figure 7.1. Obviously, self-reported health variable is not suitable for direct cross-country comparison. For some of the countries, the distribution of self-perceived health is biased towards one of the extremes. In case of Poland, the curve does not even have a single peak. This observation suggests sampling issues or, which is more likely, a country-specific response patterns.[3]

In order to analyze the source of the biases, the response distribution is to be confronted with a distribution of strongly correlated objective variable. Figure 7.2 presents a table of histograms of maximum grip strength which is considered to be a good indicator of overall health and a proxy for mortality (Ling *et al.* 2010; Sasaki *et al.* 2007; Gale *et al.* 2007). Comparison of the two tables covering the same sample indicates that the sampling was probably

[3] See Börsch-Supan & Jürges (2005) for a description of sampling methodology of SHARE in detail.

Table 7.1: Summary statistics of health and participation

Country	**Males**								**Females**							
	Exit*	HEALTH-US		HEALTH10		LIMITATION		Sample	Exit*	HEALTH-US		HEALTH10		LIMITATION		Sample
Germany	41%	3.38	2.76	6.51	7.74	38%	15%	540	48%	3.10	2.75	7.04	7.79	27%	13%	594
Sweden	25%	3.08	2.31	6.93	8.16	48%	11%	555	28%	3.20	2.36	6.86	8.16	55%	14%	637
Netherlands	40%	3.03	2.62	7.30	7.90	32%	12%	637	54%	3.03	2.52	7.38	7.93	32%	14%	786
Spain	40%	3.34	2.83	6.66	7.52	43%	8%	395	69%	3.37	2.91	6.73	7.57	26%	11%	471
Italy	54%	3.05	2.74	7.32	7.77	15%	4%	540	63%	3.11	2.80	7.39	7.74	15%	8%	469
France	31%	3.15	2.66	7.12	7.91	26%	8%	415	33%	3.10	2.78	7.41	7.89	21%	10%	475
Denmark	29%	2.92	2.17	7.26	8.30	38%	10%	647	34%	2.89	2.13	7.37	8.39	50%	12%	678
Greece	28%	2.69	2.33	7.38	7.89	19%	5%	676	63%	2.63	2.42	7.49	7.68	9%	2%	540
Switzerland	21%	2.69	2.20	7.50	8.29	27%	8%	337	35%	2.59	2.34	8.01	8.16	17%	9%	375
Belgium	49%	3.00	2.52	7.19	7.81	29%	8%	733	61%	2.94	2.57	7.34	7.91	23%	10%	752
Czech Rep.	27%	3.77	2.84	5.41	7.36	66%	12%	405	35%	3.60	2.75	5.91	7.37	60%	10%	426
Poland	63%	3.79	3.24	5.86	7.03	56%	18%	555	70%	3.67	3.16	6.18	7.31	45%	14%	541
Ireland	33%	2.78	2.15	7.23	8.02	39%	6%	225	53%	2.51	2.00	7.91	8.40	25%	9%	262
Total	38%	3.18	2.53	6.87	7.87	36%	9%	6816	50%	3.09	2.54	7.12	7.92	30%	11%	7006

For each variable a mean value is computed for workers out of the labour force (left number) and active workers (right number) separately.

** percentage of inactive people out of all respondents in the sample*

Figure 7.1: Distribution of self-perceived health by country

Source: SHARE, author's computations.

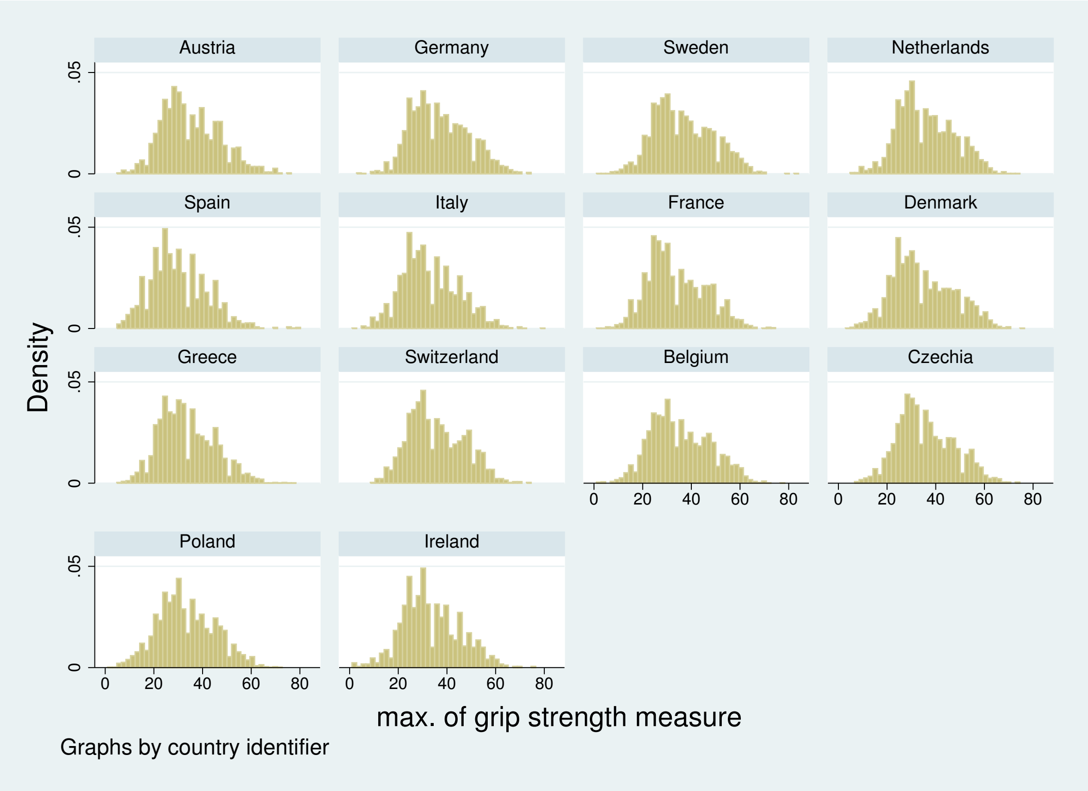
correct while specific response patterns are to be blamed for the mismatches in the first table.

A dummy counterpart to the explained (outcome) variable, labour force participation, is plotted over HEALTH-US in Figure 7.3. The aim of this thesis is to analyze observed relationship in econometrically rigorous manner, and to get a consistent bias-free estimates that would serve to evaluate the effect of policies and to make reliable forecasts.

SHARE is still a new project that is yet to fully bear its fruits. Only two regular waves were carried out and the Czech Republic joined the survey in the second one. In early 2011 a new wave was conducted. Its results will allow to make more advanced models with panel data analysis possible. So far the major problem of the survey is a discontinuity of questionnaires between the two subsequent waves. Such an issue rules out possibility of panel data analysis of some part of variables and prevents researcher from inferring dynamic and individual-specific effects. The new wave wil however introduce new interesting features such as taking blood samples and other new health measures.[4]

[4]For more information about SHARE project see www.share-project.org.

Figure 7.2: Distribution of maximum grip strength by country

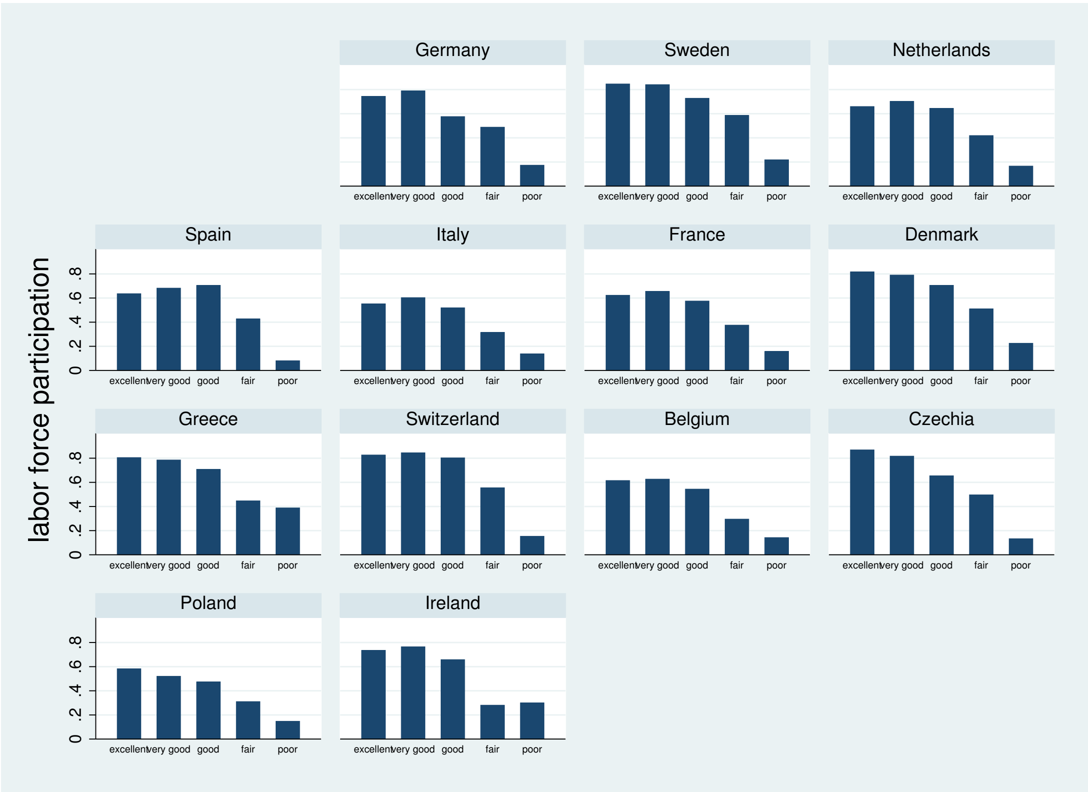


Source: SHARE, author's computations.

Table 7.2: Summary statistics – Czech males and females

	Male			Female		
	Inactive	Active	Total	Inactive	Active	Total
LIMITATION*	.35	.11	.20	.32	.11	.21
HEALTH-US	3.20	2.57	2.82	3.15	2.58	2.83
HEALTH10	6.81	7.83	7.42	6.92	7.85	7.44
age	58.30	56.95	57.32	55.19	54.30	54.70
severe conditions*	.38	.09	.17	.16	.07	.11
mild conditions*	.73	.57	.61	.67	.51	.58
ADL*	.25	.00	.07	.16	.03	.09
IADL*	.33	.02	.10	.25	.07	.15
max. grip strength	45.42	50.71	49.27	29.36	31.52	30.57
overweight*	.46	.59	.55	.19	.17	.18
obesity*	.27	.21	.23	.12	.08	.10
mentally ill*	.25	.08	.13	.36	.23	.29

Figure 7.3: Distribution of labour force participation with respect to self-perceived health



Source: SHARE, author's computations.

Chapter 8

Multidimensional nature of health

8.1 Principal Component Analysis

Early empirical studies of health effects on labour supply suffered from lack of sufficient number of objective measures and thus the statistical models employed were either underspecified or gave less credible estimates, an outcome of using weak instruments and accepting too restrictive constraints. The dataset available for the empirical research in this thesis includes over 100 variables on respondent's health.[1] This allows to significantly improve our ability to instrument subjective variables but at the same time it brings few additional difficulties:

1. Data sample consists of about 600 to 1200 observations per country, which means about 300 to 600 respondents of each gender. For a dataset of such a size, a large number of 100 binary variables makes the estimation very difficult. It is very probable that a perfect correlation with explained variable occurs and some observations and variables have to be automatically dropped.
2. Over-identification of the model by too many variables.
3. Interpreting any model of more than 100 variable is uncomfortable as we have no idea of an overall health effect.

From this perspective we prefer to work with lower number of variables and so we seek for a way to reduce the number of dimensions of our data. Fortunately, health variables are assumed to be very correlated with each other. While this assumption implies a collinearity problem for he regressions it also offers a possibility of reducing the dimensions through a so-called *principal component analysis* (PCA from now on).

[1] See Appendix B that for a full list of variables used for the analysis.

PCA is a summarisation technique involving linear orthogonal transformation (rotation) of some original data resulting in a new data where orthogonal columns (components) are ordered according to the amount of variance of original dataset they contain. Dropping some of the last components and keeping only the major part of the variance for further analysis means getting rid of the noise within the data. The procedure is fully described in (Meloun & Militky 2002; 2005) and therefore we restrict the description of the method on brief matrix formalization.

Let D be the $[n \times m]$ data matrix of n observations and m variables, where $m < n$. By centering and standardizing D^T we get to X^T. The basis for PCA is a covariance matrix $C = XX^T$. In eigenanalysis we find a solution to $X = W\Sigma V$ and obtain a diagonal matrix of square roots of eigenvalues Σ and matrix of eigenvectors (of a matrix C) W. Eigenvectors correspond to the principal components and eigenvalues to the amount of variance relevant to corresponding principal component. Both matrices are then sorted by eigenvalues (while preserving pairs of eigenvector-eigenvalue).

We are interested in a projection $Y = W_i^T X = \Sigma_i V_i^T$ and it is usual to restrict on the first $i <= max\{m, n\}$ components sorted by eigenvalues and hence to get the major part of variance from original data D into low number of variables (columns) in Y.

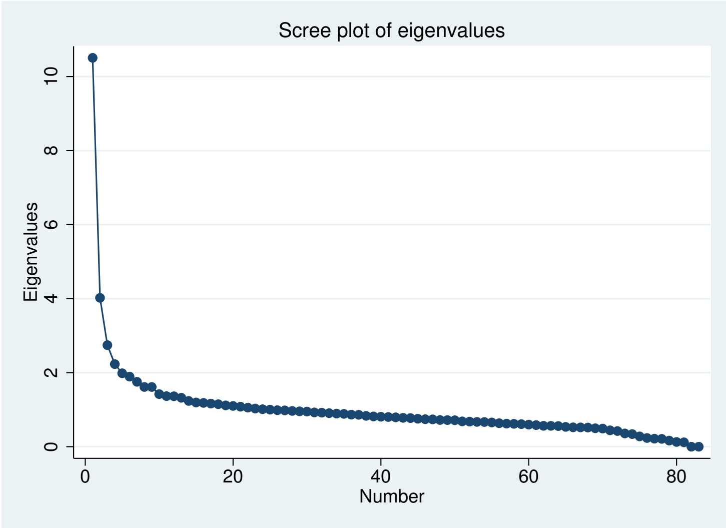
8.2 Application of PCA on a dataset of health measures and indicators

Figure 8.1 presents a screeplot from the application of PCA to the full set of objective measures and indicators from SHARE data.[2] The sample is unrestricted and contains all the countries and respondents participating in SHARE survey. It is a plot of sorted eigenvalues of a correlation matrix. This graph is used to assess the appropriate number of principal components that are to be used for further analysis (a non-linear regressions in case of this thesis).

There are two alternative popular rules of thumb to set the number of “useful” components:

[2] By full set we mean all the available variables (both continuous and dummy indicators) except for variables on general self-assessed health (SPHUS) and health limits in doing paid work – LIMITATION, all the variables are listed in Appendix B.

Figure 8.1: Screeplot from PCA of health on a pooled data sample



Source: author's computations.

1. Use all the components up to the one where the curve of eigenvalues (in a screeplot) becomes flat.

2. Use all the components of eigenvalue higher or equal to one.

The graph shows that health spreads a multidimensional space difficult to be summarized into one composite index since even the tighter of the two rules leads to keep at least 5 to 10 components.

Both these guidelines are practical while using PCA as a visual summarisation and interpretation technique, the most common use of this method. But the first principal components chosen by these rules of thumb do not necessarily have to be the components most relevant to the specific empirical economic model. If we do not want to lose even subtle but statistically and economically significant information we should rather think of some more sophisticated mechanism that picks up the right components. The technique we make use of in this place is a *stepwise procedure* that starts estimating the reporting equation of the model with all components and drop the least statistically significant step-by-step until only components of a significance above a given level remain in the regression. All the three variables of self-assessed health were given their significant regressors separately.

We run the PCA prior to the regressions. The samples of all the countries are pooled into one so that the we achive the highest possible comparability across the regressions. It is worth mentioning that the relationship between the general self-reported health measures and most of the principal components appeared to be highly nonlinear. Namely the first principal component exhibited exponential relationship to all the three variables. This fact is extremely important for those models whose identification is based on a normality assumption. For example, IV estimators disregarding such detail would lead to highly diverging and inconsistent results.

Chapter 9

Results

9.1 The naive model

The first econometric model with the simplest specification was estimated by a probit maximum likelihood estimator in terms of marginal effects on probability of being employed evaluated at the mean of the variable holding other covariates constant. A separate model for each country was estimated and thus the size of coefficients reported in Table 9.1 serves for rather illustrative purposes. Details can be found in Appendix D in Tables Table D.1 on page VIII, Table D.3 on page IX and Table D.5 on page X for men and Tables D.7, D.9 and D.11 for women.

All the estimated models reported significant negative correlation between bad self-perceived health and probability of being active, which means that **Hypothesis 1 should not be rejected** under the assuptions of the model. These findings only confirm what previous studies suggested. Unlike in Kalwij & Vermeulen (2008) this holds for all the countries engaged in SHARE. Moreover, estimated coefficients and variables of interest (LIMITATION, HEALTH-US, HEALTH10) vary only moderately across the sample. Below-average health seems play less importante role in men's early exit decision in Greece, Italy and Sweeden. On the opposite, labour supply of elderly in the Czech Republic and Belgium seems to be very sensitive to deteriorated health.

The test of **Hypothesis 2** based on significance of the interaction term $gender * health$ accepted the assumption that female labour supply is less sensitive to deteriorating health in Switzerland and Germany. For other countries, estimates followed the same pattern but relevant z-statistics were not significant.

Table 9.1: Health and employment of elderly: marginal effects

country	DE	SE	NL	SP	IT	FR	DM
males							
LIMITATION °	-0.36***	-0.42***	-0.39***	-0.45***	-0.31***	-0.32***	-0.44***
HEALTH-US	-0.18***	-0.078***	-0.10***	-0.10***	-0.06*	-0.08***	-0.11***
HEALTH10	0.09***	0.071***	0.12***	0.054**	0.04*	0.08***	0.08***
females							
LIMITATION °	-0.25***	-0.50***	-0.31***	-0.13*	-0.11	-0.26***	-0.54***
HEALTH-US	-0.08***	-0.13***	-0.14***	-0.07**	-0.05*	-0.08***	-0.14***
HEALTH10	0.06***	0.10***	0.11***	0.06***	0.03	0.05**	0.1***

*

country	GR	CH	BE	CZ	PO	IR
males						
LIMITATION °	-0.42***	-0.43***	-0.48***	-0.5***	-0.29***	-0.5***
HEALTH-US	-0.05**	-0.07***	-0.15***	-0.17***	-0.09***	-0.11**
HEALTH10	0.04**	0.06***	0.11***	0.08***	0.05***	0.05*
females						
LIMITATION °	-0.19*	-0.28**	-0.27***	-0.56***	-0.27***	-0.26**
HEALTH-US	-0.03	-0.07**	-0.09***	-0.2***	-0.11***	-0.07
HEALTH10	0.03	0.03	0.09***	0.09***	0.07***	0.06*

$p<0.05$, ** $p<0.01$, *** $p<0.001$, ° indicates discrete change of dummy variable from 0 to 1

Some of the control variables on demographic conditions revealed interesting results. Without regard to their origin, self-employed people are less likely to exit prematurely, civil employees practice this behaviour in all the countries except the Czech Republic and Poland, the only two post-communist countries in the sample, where these people exit prematurely. Also secondary school and university educated people tend to stay active until a regular retirement age.

The results are in line with Jiménez-Martín *et al.* (1999) who brought the evidence that couples often make their exit decisions jointly. Especially women's employment is significantly sensitive to the status of the spouse.

Age dummy variables responded well to specifics of given social system schemes. In case of the Czech Republic, for instance, where the early retirement is allowed no sooner then three years before a full retirement age, the last two included age dummy indicators (the last dummy indicating the last year before regular retirement age was set as baseline and therefore dropped from the regression) were not significant. In general, coefficients on age dummies tend to decrease as the age approaches the regular retirement tage, fully in line with intuitive assumption of decreasing probability of being active.

As follows from Chapter 4.1, the evidence on health effects is to be taken with caution and should not serve as a basis for too strong implications. Later in the text, some alternative estimates are presented.

9.2 Test of exogeneity

In a similar way as in case of the naive model, the tests of exogeneity were conducted for all the countries in our sample and this time even for males and females separately. For the sake of brevity only ρ values, its standard errors and level of significance relevant to acceptance (or rejection) of the null hypotheses are reported in the columns (2) of Table 9.2 for males and Table 9.3 for females. These tables further present results of both the naive regression and the IV estimation described later on.

As for the results for men, the presented figures clearly distinguish LIMITATION variable from the two remaining, HEALTH-US and HEALTH10. The test conducted with the model using LIMITATION variable rejected the null hypotheses of independent equations in most of the samples. Endogeneity issue thus arises in case of this variable in all tha countries with only two exceptions – France and Ireland. The interpretation of such differences among variables would be that respondents are influenced by the context of the question during the interview. A question "Do you have any health problem or disability that limits the kind or amount of paid work you can do?" in a clear reference to reposndent's working status may impose more incentive for a biased response than a general question like "Would you say your health is..." or "On a scale from 0 to 10, where 0 describes the worst imaginable condition and 10 describes the best imaginable condition, how do you rate your health in general?" respectively (Survey of Health & in Europe 2006). Also the fact that respondents reveal more specific part of their health in LIMITATION variable may contribute to higher significance of the simultaneity. Lack of information about respondent's health in objective variables would cause this.

The positive and negative signs of estimates of ρ are in line with the prior assumptions and predictions. Both LIMITATION and HEALTH-US, which grade worse health by higher values, were assigned negative values, while HEALTH10 which grade better health by higher numbers corresponds to positive coefficient of correlation.

Let's interpret the ρ value on the example of HEALTH10 variable which is constructed in a way that higher number means better health. If an individual exaggerates his or her health problems and reports lower grade than the true

Table 9.2: Marginal effects, endogeneity and IV estimates: males.

	LIMITATION			HEALTH-US			HEALTH10			
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	
country	dy/dx	ρ	IV dy/dx	dy/dx	ρ	IV dy/dx	dy/dx	ρ	IV dy/dx	obs
Germany	-0.36	**-0.31**	-0.52	-0.17	**-0.21**	-0.62	0.08	0.09	0.32	540
	(.054)***	(.106)**	(.059)***	(.026)***	(.074)**	(.084)***	(.014)***	(.068)	(.045)***	
Sweden	-0.40	**-0.51**	-0.58	-0.08	-0.11	-0.50	0.07	**0.15**	0.34	553
	(.054)***	(.087)***	(.074)***	(.015)***	(.071)	(.069)***	(.011)***	(.069)*	(.051)***	
Netherlands	-0.39	**-0.29**	-0.59	-0.10	-0.08	-0.56	0.12	**0.15**	0.50	636
	(.055)***	(.102)**	(.053)***	(.022)***	(.07)	(.081)***	(.019)***	(.069)*	(.067)***	
Spain	-0.45	**-0.41**	-0.58	-0.10	-0.04	-0.50	0.05	-0.08	0.31	395
	(.066)***	(.149)**	(.067)***	(.029)***	(.085)	(.103)***	(.016)**	(.08)	(.054)***	
Italy	-0.30	**-0.37**	-0.34	-0.05	-0.05	-0.30	0.03	-0.09	0.24	508
	(.079)**	(.181)*	(.094)**	(.028)	(.077)	(.118)*	(.019)	(.075)	(.067)***	
France	-0.31	-0.22	-0.49	-0.08	0.04	-0.63	0.07	0.02	0.40	411
	(.079)***	(.146)	(.093)***	(.025)**	(.088)	(.094)***	(.017)***	(.087)	(.07)***	
Denmark	-0.42	**-0.39**	-0.58	-0.10	-0.09	-0.59	0.07	0.07	0.43	645
	(.057)***	(.105)***	(.065)***	(.016)***	(.075)	(.069)***	(.012)***	(.075)	(.052)***	
Greece	-0.42	**-0.59**	-0.42	-0.05	-0.01	-0.46	0.03	-0.04	0.35	656
	(.08)***	(.116)***	(.112)***	(.019)**	(.069)	(.096)***	(.013)*	(.069)	(.067)***	
Switzerland	-0.39	**-0.56**	-0.57	-0.06	-0.06	-0.56	0.06	0.10	0.46	336
	(.089)***	(.148)***	(.111)***	(.019)***	(.11)	(.116)***	(.012)***	(.107)	(.072)***	
Belgium	-0.46	**-0.36**	-0.57	-0.13	-0.07	-0.67	0.10	0.00	0.51	732
	(.049)***	(.099)***	(.045)***	(.024)***	(.067)	(.077)***	(.02)***	(.066)	(.064)***	
Czech. Rep.	-0.49	**-0.58**	-0.66	-0.16	**-0.21**	-0.89	0.08	**0.21**	0.44	405
	(.056)***	(.098)***	(.061)***	(.024)***	(.094)*	(.089)***	(.011)***	(.086)*	(.047)***	
Poland	-0.35	**-0.50**	-0.41	-0.10	-0.03	-0.49	0.06	0.06	0.29	530
	(.041)***	(.095)***	(.054)***	(.025)***	(.079)	(.088)***	(.013)***	(.073)	(.048)***	
Ireland	-0.39	**-0.47**	-0.47	-0.09	-0.08	-0.49	0.05	0.01	0.27	225
	(.106)***	(.186)*	(.136)**	(.033)**	(.117)	(.136)***	(.022)*	(.114)	(.095)**	

(1) – marginal effects estimates from “naive” model; (2) – SUR simultaneity measured as correlation of errors; (3) – IV estimates in terms of marginal effects; * p<0.05, ** p<0.01, *** p<0.001, ° indicates discrete change of dummy variable from 0 to 1; bold font indicates rejection of null hypothesis of exogeneity.

Table 9.3: Marginal effects, endogeneity and IV estimates: females.

	LIMITATION			HEALTH-US			HEALTH10			
	(1)	**(2)**	**(3)**	**(1)**	**(2)**	**(3)**	**(1)**	**(2)**	**(3)**	
country	dy/dx	ρ	IV dy/dx	dy/dx	ρ	IV dy/dx	dy/dx	ρ	IV dy/dx	obs
Germany	-0.22 (.055)***	-0.11 (.103)	-0.42 (.061)***	-0.07 (.024)**	-0.04 (.064)	-0.35 (.087)***	0.05 (.014)***	0.06 (.061)	0.22 (.05)***	593
Sweden	-0.46 (.046)***	**-0.55** (.081)***	-0.60 (.057)***	-0.12 (.015)***	**-0.18** (.068)**	-0.62 (.062)***	0.09 (.011)***	**0.18** (.067)**	0.49 (.044)***	636
Netherlands	-0.31 (.04)***	**-0.23** (.086)**	-0.48 (.04)***	-0.13 (.021)***	**-0.14** (.058)*	-0.57 (.07)***	0.11 (.017)***	**0.14** (.055)**	0.45 (.06)***	785
Spain	-0.15 (.049)**	-0.07 (.139)	-0.24 (.061)**	-0.07 (.024)**	-0.10 (.085)	-0.39 (.113)***	0.06 (.015)***	0.10 (.081)	0.38 (.071)***	471
Italy	-0.11 (.069)	-0.12 (.153)	-0.26 (.083)*	-0.05 (.025)	-0.14 (.072)	-0.09 (.115)	0.02 (.019)	0.06 (.072)	0.08 (.075)	469
France	-0.24 (.074)***	-0.24 (.134)	-0.41 (.106)***	-0.08 (.025)**	-0.12 (.081)	-0.38 (.113)***	0.05 (.018)**	0.07 (.074)	0.28 (.085)**	444
Denmark	-0.51 (.045)***	**-0.58** (.084)***	-0.63 (.049)***	-0.13 (.017)***	-0.10 (.065)	-0.60 (.06)***	0.09 (.012)***	0.10 (.062)	0.43 (.044)***	677
Greece	-0.19 (.083)	-0.06 (.299)	-0.34 (.038)***	-0.03 (.028)	0.06 (.075)	-0.40 (.126)**	0.02 (.018)	-0.01 (.073)	0.21 (.075)**	542
Switzerland	-0.31 (.089)***	**-0.35** (.133)**	-0.47 (.145)**	-0.08 (.028)**	**-0.16** (.084)*	-0.26 (.129)*	0.03 (.018)	-0.01 (.083)	0.13 (.077)	374
Belgium	-0.26 (.043)***	**-0.25** (.101)*	-0.40 (.042)***	-0.09 (.022)***	-0.09 (.061)	-0.48 (.087)***	0.09 (.018)***	**0.12** (.059)*	0.39 (.071)***	752
Czech. Rep.	-0.54 (.052)***	**-0.71** (.076)***	-0.56 (.072)***	-0.18 (.029)***	**-0.24** (.081)**	-0.77 (.098)***	0.09 (.014)***	**0.19** (.08)*	0.34 (.05)***	426
Poland	-0.27 (.035)***	**-0.41** (.092)***	-0.35 (.048)***	-0.11 (.021)***	**-0.14** (.073)*	-0.55 (.093)***	0.07 (.012)***	**0.18** (.07)**	0.35 (.054)***	540
Ireland	-0.28 (.08)**	-0.28 (.197)	-0.35 (.09)**	-0.07 (.033)*	-0.02 (.117)	-0.32 (.108)**	0.06 (.023)*	0.05 (.101)	0.23 (.081)**	262

(1) – marginal effects estimates from "naive" model; (2) – SUR simultaneity measured as correlation of errors; (3) – IV estimates in terms of marginal effects; * p<0.05, ** p<0.01, *** p<0.001, ^{o} indicates discrete change of dummy variable from 0 to 1; bold font indicates rejection of null hypothesis of exogeneity.

one a negative residual in reporting equation occurs. When ρ is positive, this negative residual implies a negative residual in the participation equation and thus the true (fitted) probability of being employed is higher than the one observed. In this case an inactive (unemployed) individual reported worse health than the objective measures suggested.

As for the results for women, estimates do not distinguish variables as they do distinguish countries. France, Italy, Spain, Greece, Germany and Ireland do not show any sign of systematic reporting bias among women as all the other countries do. Significant level of simultaneity was evident especially in the Czech Republic, Sweeden but also in Netherlands and Poland.

9.3 IV estimates

A summary of results from the IV regressions is presented in the same tables. Columns (3) list the marginal effects the variable in question has on the probability of being employed evaluated at the mean of this covariate, all other covariates keeping constant. Again, each value represents an independent estimate for each country.

For a brief comparison with the model treating self-perceived health as exogenous variable see the marginal effects estimates in columns (1). The difference between these two types of estimates carries the opposite sign than justification hypothesis suggested.[1] The importance of health as an explanatory variable considerably increased with IV method of estimation which indicates either a random measurement error issue in all the three self-reported health status variables or mispesification of the reporting structural equation. Note that the dummy variable LIMITATION seems to be less prone to these errors (as we observe lower differences between IV and original estimates) but more likely there is just a larger contra-effect of justification bias as exogeneity test in section 9.2 suggested. The results are now also much more comparable across all the three variables.

R^2 (resp. McFadden's pseudo R^2 in case of binary response LIMITATION variable) are not reported in the table but they allowed to get the picture of goodness of fit of the "first-stage" reporting equation 6.7.[2] It showed how far a

[1] Let us remind that the IV estimates were expected to show lower importance of health then the naive estimates as being free of systmic exxageration of health by inactive workers

[2] The term "first-stage" is in quotation marks as the model was not estimated in a two-stage regression. The R^2 values come from auxiliary regressions.

self-perceived health can be explained by objective variables. The level, which was usually about 50 %, is high enough not to call the instruments weak. It also has a lot to do with the amount of measurement error in a given endogenous variable. The more we are able to explain the variance in endogenous variable the less random measurement error we observe.

The differences in marginal effects among the countries did not change dramatically. The Czech Republic remains on the top of the list while Italy, Greece or Poland stay behind on the tail. Getting rid of the measurement error, the model has been highly improved (in terms of significance of estimated coefficients) in Ireland, Greece or Italy. Differences among countries are further analyzed in Chapter 9.4.

Hypothesis 1 was not rejected even in a framework of IV regression. Estimates less affected by systematic bias proved to be even more significant, probably because of getting rid of the random measurement error inherent to all kinds of variables based on subjectively perceived measures.

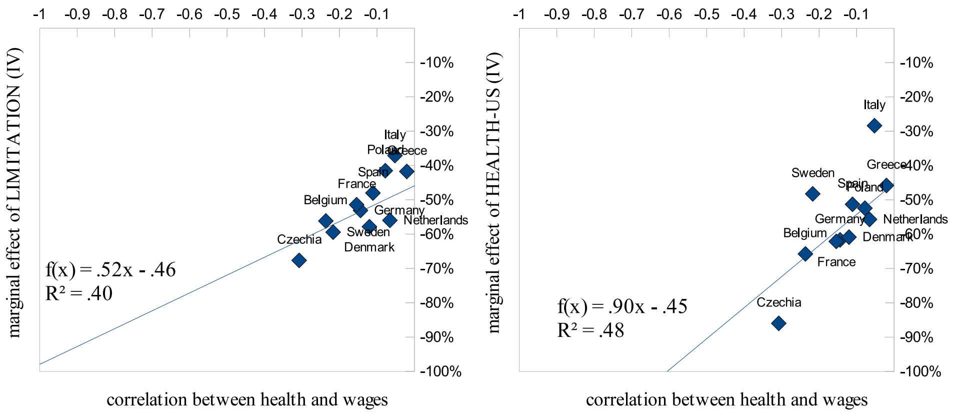
Hypothesis 2 claiming that labour force participation of women is less sensitive to changes in health was tested by a Chow test putting principal components of health directly into the outcome equation and was accepted within the models of early exit behaviour in Switzerland, the Czech Republic and France. Detailed results of the test are reported in Appendix D.

9.4 Health and wages

The differences in marginal effects among different countries may be explained by differences on the demand side of the labour market. When productivity (and consequently a wage) of a worker is more dependent on his health, a greater effects shall be assumed.

Data from a single wave of the survey do not allow to include wages and other compensations directly into the econometric model as we do observe this information only for active respondents. To confirm the intuition suggesting that the higher is the dependence of wages on health, the greater effect health has on participation, we include a “meta analysis” of results from all the estimated regressions. The effect of health on probability of early exit is to be compared with correlation between wages and health for all the countries in the sample. Figure 9.1 illustrates the relationship for active male participants of SHARE. Apparently higher marginal effect corresponds to a higher correlation between wages and health. What is more, we assume the slope to be

Figure 9.1: Health effect on participation vs. wage dependence on health



The vertical axis represents marginal effects on variables of health, the horizontal axis represents correlation between wages and health in given country.

highly underestimated due to the fact that early inactive (unemployed) workers had to be dropped from the sample (as we do not observe their hypothetical wages) and we assume the correlation between their health and wages to be significantly higher.

The workhorse of the relationship are the Czech Republic with the greatest effect of health on employment and wages and Italy being on the opposite side of the cluster. The reasoning behind this is that in more heavy-industry-oriented or let's say labour intensive economies decline in health capacity implies more serious barrier to employment than in an economy more oriented on commerce and services. If in the economy a worker's wage is related to his health, this worker has lower incentives to stay on the labour market when his health deteriorates. On this place, we would like to remind the reverse causality problem again. Not only health can affect the level of wage but also higher wage may contribute (through higher spending on health care) to better health and and vice versa.

Although we did not provide a rigorous test of the relationship, the analysis suggests the need to implement the relationship between wages and health into the model of early exit behaviour as another endogenous covariate with a separate structural equation once new waves of SHARE and new data are available.

9.5 Discussion

Previous analysis of SHARE in Kalwij & Vermeulen (2008) did not provide a sharp evidence of endogeneity in responses. Howeever, it suggested existence of differences among countries engaged in the survey. Advanced econometric methods presented in this study showed results which are basically in line with findings by Dwyer & Mitchell (1998) once we consider only male respondents. In that case there is an evidence of justification bias in variable on health limitations (LIMITATION) but its magnitude and effect on the outcome variable seems to be rather low. Only two countries exhibited biased responses from their inhabitants in a sense that all the three variables are suspected from bias; these are the Czech Republic and Sweden. Otherwise, we have seen that the response patterns are quite homogeneous across the countries in question. On the other hand, responses of females were independent on differences in questions on their health in the questionaire as they were dependenton nationality.

While the method of seemingly unrelated regression allows for diagnosing the endogeneity problem, it cannot give us any clear inference on the actual effect on estimates – the size of possible bias. Neither does it control for random measurement error, another issue related to health variables in econometric models. Method of instrumental variables estimation provided estimates less affected by endogeneity and random measurement error. These two issues have the opposite impacts on the estimates of imporatance of health. While systematic error (due to justification bias) increase the effect, random measurement error in variable decreases the significance of the effect on the outcome variable – the probability of staying on the labour market. What we observe in differences between the original and the IV estimates is a sum of these two "contradictory" effects. A comparison of IV and normal estimates thus gives ambiguous answer to the question of justification hypothesis. But using IV analysis at least provided more reliable tests of Hypothesis 1 (concerning significance of the negative effect of subnormal health on participation). To test Hypothesis 2 (concerning females' lower sensitivity to health in therms of participation) we had to employ principal components of health directly into the reduced form outcome equation.

Finally, we do not recommend to continue using IV method to control for endogeneity due to reporting bias in retirement models unless more theoretical and empirical analysis is devoted to the reporting equation specification. We observed highly nonlinear relation ship between principal components and subjective measures of health. Potential misspecification in this part of the structural model would lead to bias in fitted endogenous explaining variable and would result in biased estimates of coefficients in the outcome equation. On this place, we would recommand using the objective information instead, whenever the data are available.

Principal component analysis did a great job by summarizing multidimensional set of information on health into a low number of variables useful in regressions. This technique popular for the purpose of visual interpretation of multidimensional data allowed for extracting effective part of information spread in too wide data matrix. It allowed to analyze the simultaneity issue (Hypothesis 3) and also to employ the objective variables directly into the outcome equation of the model to double-check the test of Hypothesis 2.

The presented models controled for reporting biases as sources of endogeneity. Nevertheless, they still did not allow to control for potential reverse causality issue and hence we should rather avoid implying causal effects and stay with using the less bold term “association” instead of “causality”.

Chapter 10

Conclusion

This thesis met most of the aims it has taken. It confirmed that bad health is associated with lower probability of older men and women being employed across all the countries participating in the second wave of Survey of Health, Ageing and Retirement regardless of researcher's choice between self-percieved and objective measures. It showed that in case of the Czech Republic, France and Switzerland this effect is significantly lower for women than for men and that it increases with the magnitude how far are wages correlated with health.

The central point of the thesis lies elsewhere, though. It was shown that inactive people in most of the surveyed countries tend to underrate their health, which brings endogeneity issue into identification of empirical retirement models which use variables based on subjective measures of health that may result in biased (underestimated) and less efficient estimates of coefficients on these variables. Using objective variables increases the size of estimated effect by which health influences employment. This poses a question on employing self-reported measure of health in retirement modelling. Yet, we appreciate including these measures in surveys as they help to analyze social and psychological conditions of respondents. They may also contribute to separate the supply and the demand side of the analysed association between health and labour force particiaption.

Nevertheless, using objective information to measure health is a non-trivial task as well. We showed that health is of rather multi-dimensional nature and therefore cannot be easily summarized into a single composite index. Furthermore, using instrumental variable method may introduce additional bias if the non-linear relationship between self-percieved health and objective measures of health is ignored.

Models of retirement are of a complex nature. Instead of aiming to get the most general and best-fitted empirical model, we decided to restrict the explanatory power of our models to capture and analyse specific isolated research questions. Health changes are exemplary cases of unanticipated random events that cannot be easily controlled for in advanced life-cycle models. In this regard our simple static wage-leisure models do not lose on generality.

While the presented analysis successfully empirically tested most of the hypotheses, much work in this area is yet to be done. Adjustment for differences in social security and social insurance systems in the presented models was limited on controling for normal and early retirement age thresholds in given countries. With data from new waves of SHARE project, it will be possible to implement replacement ratios and other incentive measures into the model. Observing present wages of future retirees will also allow for better distinguishing labour supply and labour demand. Longitudinal character of the survey will also allow us to apply a panal data analysis and thus control for individual-specific and time-specific effects. Dynamic properties such as sudden health changes, health shocks, and their impact on labour force will be subject of further analysis.

Interesting area of research that deserve an attention of labour economists is the impact of recent economic recession on early and regular retirement behavioural patterns and changes in health elasticity of labour supply and demand.

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Appendix A

Estimation

A.1 MLE estimators

Bivariate probit model with and without an endogenous dummy regressor

$$p^* = \lambda_1\eta^* + \beta_1 X_1 + \varepsilon_1$$

$$h = \lambda_2\eta^* + \beta_2 X_2 + \varepsilon_2$$

where we observe the participation status lf in a way that

$$lf_i = \begin{cases} 1 & if \;\; p_i^* > 0 \\ 0 & if \;\; p_i^* \leq 0 \end{cases}$$

The log-likelihood to be maximalized is written as:

$$\begin{aligned} lnL &= \sum_{i=1}^{N}\{lf_i h_i ln\Phi_2(\lambda_1\eta^* + \beta_1 X_1; \lambda_2\eta^* + \beta_2 X_2; \rho) \\ &+ lf_i(1-h_i)ln[\Phi(\lambda_1\eta^* + \beta_1 X_1) - \Phi_2(\lambda_1\eta^* + \beta_1 X_1; \lambda_2\eta^* + \beta_2 X_2; \rho)] \\ &+ (1-lf_i)h_i ln[\Phi(\lambda_2\eta^* + \beta_2 X_2) - \Phi_2(\lambda_1\eta^* + \beta_1 X_1; \lambda_2\eta^* + \beta_2 X_2; \rho)] \\ &+ (1-lf_i)(1-h_i)ln[1 - \Phi(\lambda_1\eta^* + \beta_1 X_1) - \lambda_2\eta^* + \beta_2 X_2) \\ &- \Phi_2(\lambda_1\eta^* + \beta_1 X_1; \lambda_2\eta^* + \beta_2 X_2; \rho)] \end{aligned}$$

assuming

$$E[\varepsilon_1|\eta^*, X_1, X_2] = E[\varepsilon_2|\eta^*, X_1, X_2] = 0$$

$$Var[\varepsilon_1|\eta^*, X_1, X_2] = Var[\varepsilon_2|\eta^*, X_1, X_2] = 1$$

$$Cov[\varepsilon_1, \varepsilon_2|\eta^*, X_1, X_2] = \rho$$

Mixed-process bivariate models of *probit* / *ordered probit* were estimated using STATA *cmp* command following Roodman (2009).

Appendix B

List of variables

number	SHARE notation	thesis notation	description
0	ep005_	outcome variable	employed
1	ph061_	LIMITATIONS °	any limitation to do a paid job
2	sphus	HEALTH-US	excellent, very good, good, bad, poor
3	ph060	HEALTH10	scale 1–10, (the higher the better health)
4	mstat	marital status °	married
5	ep005_	spouse's status °	spouse is employed
6	ch001_	num. of children	number of children
7	areabldg	lives in a city °	lives in a city
8	areabldg	lives in a town °	lives in a town
9	areabldg	lives in rural °	lives in countryside
10	ep009_ ep019_ ep051_ ep055_	civil employee °	civil employee
11	ep009_ ep051_	self_employed °	work as self-employed
12	isced_r	secondary ed. °	secondary school education
13	isced_r	university ed. °	universtity education

° indicates a dummy/indicator variable.

number	variable	description
1	ph006d1	doctor told you had: heart attack
2	ph006d2	doctor told you had: high blood pressure or hypertension
3	ph006d3	doctor told you had: high blood cholesterol
4	ph006d4	doctor told you had: stroke
5	ph006d5	doctor told you had: diabetes or high blood sugar
6	ph006d6	doctor told you had: chronic lung disease
7	ph006d7	doctor told you had: asthma
8	ph006d8	doctor told you had: arthritis
9	ph006d9	doctor told you had: osteoporosis
10	ph006d10	doctor told you had: cancer
11	ph006d11	doctor told you had: stomach or duodenal ulcer, peptic ulcer
12	ph006d12	doctor told you had: parkinson disease
13	ph006d13	doctor told you had: cataracts
14	ph006d14	doctor told you had: hip fracture or femoral fracture
15	ph006d15	doctor told you had: other fractures
16	ph006d16	doctor told you had: alzheimer's disease, dementia, senility
17	ph006d17	doctor told you had: benign tumor
18	ph006dno	doctor told you had: none
19	ph006dot	doctor told you had: other conditions
20	ph010d1	bothered by: pain in back, knees, hips or other joint
21	ph010d2	bothered by: heart trouble
22	ph010d3	bothered by: breathlessness
23	ph010d4	bothered by: persistent cough
24	ph010d5	bothered by: swollen legs
25	ph010d6	bothered by: sleeping problems
26	ph010d7	bothered by: falling down
27	ph010d8	bothered by: fear of falling down
28	ph010d9	bothered by: dizziness, faints or blackouts
29	ph010d10	bothered by: stomach or intestine problems
30	ph010d11	bothered by: incontinence
31	ph010d12	bothered by: fatigue
32	ph010dno	bothered by: no symptoms
33	ph010dot	bothered by: other symptoms
34	ph011d1	drugs for: high blood cholesterol
35	ph011d2	drugs for: high blood pressure
36	ph011d3	drugs for: coronary diseases
37	ph011d4	drugs for: other heart diseases
38	ph011d5	drugs for: asthma
39	ph011d6	drugs for: diabetes
40	ph011d7	drugs for: joint pain
41	ph011d8	drugs for: other pain
42	ph011d9	drugs for: sleep problems

number	variable	description
43	ph011d10	drugs for: anxiety or depression
44	ph011d11	drugs for: osteoporosis, hormonal
45	ph011d12	drugs for: osteoporosis, other
46	ph011d13	drugs for: stomach burns
47	ph011d14	drugs for: chronic bronchitis
48	ph011dno	drugs for: none
49	ph011dot	drugs for: other
50	ph041_	use glasses
51	ph048d1	difficulties: walking 100 metres
52	ph048d2	difficulties: sitting two hours
53	ph048d3	difficulties: getting up from chair
54	ph048d4	difficulties: climbing several flights of stairs
55	ph048d5	difficulties: climbing one flight of stairs
56	ph048d6	difficulties: stooping, kneeling, crouching
57	ph048d7	difficulties: reaching or extending arms above shoulder
58	ph048d8	difficulties: pulling or pushing large objects
59	ph048d9	difficulties: lifting or carrying weights over 5 kilos
60	ph048d10	difficulties: picking up a small coin from a table
61	ph048dno	difficulties: none of these
62	ph049d1	difficulties: dressing, including shoes and socks
63	ph049d2	difficulties: walking across a room
64	ph049d3	difficulties: bathing or showering
65	ph049d4	difficulties: eating, cutting up food
66	ph049d5	difficulties: getting in or out of bed
67	ph049d6	difficulties: using the toilet, incl. getting up or down
68	ph049d7	difficulties: using a map in a strange place
69	ph049d8	difficulties: preparing a hot meal
70	ph049d9	difficulties: shopping for groceries
71	ph049d10	difficulties: telephone calls
72	ph049d11	difficulties: taking medications
73	ph049d12	difficulties: doing work around the house or garden
74	ph049d13	difficulties: managing money
75	ph049dno	difficulties: none of these
76	orienti	orientation to date, month, year and day of week
77	mental_ill	cathegory of EURO-D depression scale
78	iadl	limitations with instrumental activities of daily living
79	adl	number of limitations with activities of daily living
80	maxgrip	max. of grip strength measure
81	numeracy	numeracy score: mathematical performance
82	bmi	body mass index

Appendix C

Retirement age in surveyed countries

* The normal retirement age in the Czech Republic is in a continuous progress since 1996. It gradually increase by two months every year from 60 until it reaches the age of 65. The age of retirement for women is lowered by the number of children by up to four years. This age gradually increase by four months every year starting at 57 (53 for women with five children) and reaching 65 (62 for women with at least four children).

SHARE code	**country**	**regular retirement**		**early retirement**
		women	**men**	men/women
23	Belgium	65	64	60
28	Czech Republic*	approx 61.5	approx 56 to 59	3 years before
18	Denmark	65	65	60
17	France	60	60	-
12	Germany	65	65	63
19	Greece	65	60	60/55
30	Ireland	65	65	60
16	Italy	65	60	57
14	Netherlands	65	65	60
29	Poland	65	60	60/55
13	Sweden	65	65	61
15	Spain	65	65	60
20	Switzerland	65	64	63/61

Appendix D

Regression reports

Explanatory notes

Significance levels:* $p<0.05$, ** $p<0.01$, *** $p<0.001$

^{o} indicates a discrete change of dummy variable from 0 to 1

Table D.1: LIMITATION: Marginal effects on probability of being active: men

country code	DE	SE	NL	SP	IT	FR	DM	GR	CH	BE	CZ	PO	IR
marital status °	0.116	0.0853	0.0647	0.219*	0.132	-0.0248	0.0643	-0.0263	-0.0114	0.0500	0.0647	0.155***	-0.00938
spouse's status °	0.0294	0.0550	0.0743	0.0734	-0.121	0.105*	0.173***	0.105**	0.0329	0.0183	0.0176	0.127*	0.117
num. of children	0.0499*	0.000914	0.0251	-0.0275	0.0180	-0.0510**	0.0253	-0.0433*	0.0272	0.0494*	-0.00897	-0.0194	0.0201
lives in a city °	-0.0108	0.0823	-0.0941	0.118	0.131	0.0764	0.0211	-0.0235	-0.0648	0.0442	0.117*	0.0107	0.121
lives in a town °	-0.0530	0.0571	-0.0946	0.0154	0.0336	0.0173	0.0544	-0.0851	-0.0984	-0.0522	0.0931	-0.0118	0.184*
civil emploee °	0.174**	0.0620	0.171***	0.221***	0.247**	0.225***	0.165***	0.174***	0.0218	0.545***	-0.240***	-0.180***	0.0297
self_employed °	0.390***	0.0960*	0.262***	0.407***	0.444***	0.187***	0.215***	0.380***	0.137***	0.537***	0.0235	0.236**	0.340***
secondary ed. °	-0.0431	0.0656	0.0860	-0.0716	0.140	0.109	-0.0203	-0.0663	0.106	-0.272*	0.0742	0.143**	-0.0503
university ed. °	0.0616	0.184**	0.178*	0.0751	0.238***	0.128	-0.0564	0.139*	0.143	0.224*	0.150**	0.323***	-0.0500
age of 50 °		0.165***			0.553***	0.276***	0.209***	0.177***			0.200***	0.804***	
age of 51 °	0.421***	0.177***	0.431***	0.435***	0.592***	0.267***	0.256***	0.206***	0.139***	0.524***	0.197***	0.911***	0.200
age of 52 °	0.414***	0.189***	0.404***	0.425***	0.597***	0.246***	0.267***	0.150*	0.169***	0.553***	0.176**	0.897***	0.270**
age of 53 °	0.424***	0.117*	0.407***	0.380***	0.563***	0.284***	0.263***	0.190***	0.151***	0.536***	0.190***	0.916***	0.240
age of 54 °	0.416***	0.186***	0.406***	0.440***	0.571***	0.283***	0.253***	0.221***	0.160***	0.521***	0.126	0.914***	
age of 55 °	0.462***	0.201***	0.400***	0.394***	0.571***	0.245***	0.241***	0.175***	0.155***	0.547***	0.179**	0.909***	0.264*
age of 56 °	0.437***	0.211***	0.415***	0.361***	0.564***	0.209***	0.239***	0.184***	0.142***	0.539***	0.216***	0.914***	0.299***
age of 57 °	0.452***	0.140**	0.408***	0.383***	0.551***	0.236***	0.243***	0.129	0.150***	0.529***	0.162**	0.857***	0.201
age of 58 °	0.426***	0.153***	0.369***	0.383***	0.488***	0.0107	0.264***	0.108	0.142***	0.465***	0.0917	0.890***	0.308***
age of 59 °	0.397***	0.180***	0.349***	0.385***	0.450***	-0.0218	0.244***	0.112	0.136***	0.488***	0.0667	0.897***	0.0639
age of 60 °	0.356***	0.123*	0.324***	0.318**	0.368*		0.231***	0.147*	0.126***	0.449***		0.883***	-0.213
age of 61 °	0.273**	0.134**	0.260*	0.358***	0.356*		0.215***	0.0327	0.139***	0.227		0.863***	0.0110
age of 62 °	0.239*	0.0970	0.197	0.281	0.350*		0.201***	-0.0305	0.114***	0.206		0.862***	-0.366
age of 63 °	0.174	0.0543	0.0394	0.210	0.314		0.184***	-0.0319	0.111***	0.278		0.854***	-0.375
age of 64 °	0.00826	-0.0912	-0.0377	0.302*	0.351*		0.0580	-0.0927	0.0648	0.248		0.834***	0.116
LIMITATION °	**-0.358*****	**-0.416*****	**-0.386*****	**-0.448*****	**-0.309*****	**-0.324*****	**-0.440*****	**-0.420*****	**-0.427*****	**-0.480*****	**-0.495*****	**-0.292*****	**-0.495*****
Observations	534	553	631	392	539	415	645	676	335	732	405	555	209
Pseudo R^2	0.334	0.257	0.357	0.341	0.371	0.304	0.430	0.322	0.343	0.495	0.354	0.376	0.372

Table D.3: HEALTH-US: Marginal effects on probability of being active: men

country code	**DE**	**SE**	**NL**	**SP**	**IT**	**FR**	**DM**	**GR**	**CH**	**BE**	**CZ**	**PO**	**IR**
marital status °	0.0932	0.125	0.0792	0.243**	0.136	-0.0513	0.0706	-0.0521	-0.0178	0.0491	0.0306	0.164***	0.0499
spouse's status °	0.0274	0.0705	0.0637	0.0475	-0.127	0.107*	0.169***	0.114**	0.0225	0.0289	0.0486	0.159**	0.134
num. of children	0.0480*	-0.00192	0.0222	-0.0479*	0.0126	-0.0504**	0.0248	-0.0350	0.0342	0.0407*	-0.00748	-0.0265	0.0173
lives in a city °	-0.0140	0.0636	-0.0809	0.198*	0.132	0.0988	0.00685	0.0234	-0.0596	0.0365	0.131**	0.00892	0.139
lives in a town °	0.0110	0.0662	-0.0939	0.0668	0.0323	0.0421	0.0217	-0.0491	-0.0935	-0.0736	0.0975*	-0.0186	0.162
civil emploee °	0.192**	0.0321	0.142**	0.220***	0.227**	0.231***	0.165***	0.180***	0.0181	0.530***	-0.272***	-0.172***	0.0344
self_employed °	0.392***	0.0932*	0.237***	0.425***	0.440***	0.187***	0.206***	0.361***	0.128***	0.532***	-0.0171	0.206**	0.374***
secondary ed. °	-0.177	0.0885	0.104	0.0186	0.132	0.146*	-0.0432	-0.0605	0.104	-0.314*	0.0840	0.139**	-0.0351
university ed. °	-0.0659	0.168*	0.208**	0.114	0.235***	0.179	-0.0610	0.176**	0.144	0.160	0.157***	0.264**	-0.0543
age of 50 °		0.130			0.557***	0.275***	0.204***	0.161**			0.219***	0.786***	
age of 51 °	0.406***	0.174***	0.441***	0.435***	0.596***	0.269***	0.253***	0.213***	0.161***	0.525***	0.223***	0.894***	0.265**
age of 52 °	0.403***	0.205***	0.407***	0.416***	0.598***	0.251***	0.259***	0.170***	0.193***	0.551***	0.201***	0.879***	0.303***
age of 53 °	0.412***	0.120*	0.410***	0.381***	0.570***	0.274***	0.261***	0.183***	0.166***	0.541***	0.221***	0.899***	0.282***
age of 54 °	0.404***	0.194***	0.407***	0.436***	0.578***	0.280***	0.251***	0.222***	0.177***	0.520***	0.172***	0.898***	
age of 55 °	0.456***	0.202***	0.409***	0.390***	0.579***	0.233***	0.239***	0.172**	0.175***	0.552***	0.200***	0.892***	0.293***
age of 56 °	0.430***	0.214***	0.422***	0.367***	0.575***	0.214***	0.231***	0.183***	0.163***	0.543***	0.228***	0.897***	0.317***
age of 57 °	0.441***	0.144**	0.414***	0.379***	0.561***	0.236***	0.236***	0.128	0.167***	0.533***	0.209***	0.836***	0.261*
age of 58 °	0.407***	0.160***	0.369***	0.386***	0.519***	0.0270	0.259***	0.0867	0.167***	0.472***	0.160**	0.872***	0.301***
age of 59 °	0.387***	0.158***	0.343***	0.382***	0.491***	-0.0207	0.240***	0.107	0.158***	0.492***	0.136*	0.878***	0.164
age of 60 °	0.357***	0.105	0.327***	0.310**	0.406**		0.230***	0.141*	0.144***	0.454***		0.864***	-0.0872
age of 61 °	0.244*	0.118*	0.259*	0.379***	0.415**		0.210***	0.0188	0.153***	0.247		0.841***	0.0552
age of 62 °	0.223	0.0765	0.214	0.284*	0.414**		0.203***	-0.0638	0.133***	0.228		0.842***	-0.158
age of 63 °	0.112	0.0599	0.0530	0.230	0.330		0.185***	-0.0489	0.130***	0.329*		0.832***	-0.212
age of 64 °	-0.0150	-0.106	-0.0132	0.327**	0.408**		0.0633	-0.109	0.0706	0.250		0.815***	0.160
HEALTH-US	**-0.182***	**-0.0778***	**-0.102***	**-0.103***	**-0.0598***	**-0.0832***	**-0.113***	**-0.0510****	**-0.0671***	**-0.148***	**-0.165***	**-0.0868***	**-0.106****
Observations	534	555	632	392	540	415	647	676	336	732	405	555	209
Pseudo R^2	0.347	0.193	0.329	0.292	0.362	0.291	0.412	0.290	0.298	0.466	0.297	0.323	0.334

Table D.5: HEALTH10: Marginal effects on probability of being active: men

country code	DE	SE	NL	SP	IT	FR	DM	GR	CH	BE	CZ	PO	IR
marital status ^{o}	0.105	0.0956	0.0609	0.222*	0.142	-0.0410	0.0749	-0.0409	-0.0268	0.0512	0.0539	0.180***	0.0760
spouse's status ^{o}	-0.0170	0.0665	0.0705	0.0456	-0.125	0.108*	0.170***	0.114**	0.0320	0.0304	0.0412	0.147*	0.126
num. of children	0.0523*	-0.00293	0.0301	-0.0438	0.0154	-0.0510**	0.0215	-0.0358	0.0419*	0.0437*	-0.00633	-0.0250	0.0133
lives in a city ^{o}	0.000456	0.0693	-0.0882	0.168	0.128	0.102	0.0283	0.0286	-0.0748	0.00805	0.115*	0.0150	0.145
lives in a town ^{o}	-0.00137	0.0551	-0.105	0.0511	0.0335	0.0287	0.0578	-0.0475	-0.0882	-0.0727	0.0642	-0.00295	0.166*
civil employee ^{o}	0.173**	0.0399	0.158**	0.238***	0.228**	0.213***	0.161***	0.181***	0.0267	0.539***	-0.256***	-0.157***	0.0255
self_employed ^{o}	0.382***	0.0831	0.232***	0.421***	0.436***	0.182***	0.211***	0.359***	0.138***	0.526***	-0.00300	0.217**	0.357***
secondary ed. ^{o}	-0.0803	0.0861	0.0968	0.0297	0.139	0.175**	-0.0119	-0.0519	0.131	-0.278*	0.0899	0.137**	-0.0331
university ed. ^{o}	0.0354	0.161*	0.210**	0.112	0.227***	0.201*	-0.0542	0.195**	0.177	0.166	0.169***	0.268**	-0.0541
age of 50 ^{o}		0.187***			0.556***	0.279***	0.206***	0.165**			0.225***	0.788***	
age of 51 ^{o}	0.403***	0.163**	0.438***	0.435***	0.595***	0.263***	0.261***	0.213***	0.148***	0.526***	0.229***	0.895***	0.285***
age of 52 ^{o}	0.408***	0.202***	0.402***	0.416***	0.599***	0.255***	0.266***	0.158**	0.180***	0.545***	0.208***	0.880***	0.311***
age of 53 ^{o}	0.420***	0.105	0.406***	0.379***	0.568***	0.281***	0.273***	0.183***	0.153***	0.537***	0.226***	0.900***	0.289***
age of 54 ^{o}	0.401***	0.189***	0.405***	0.434***	0.577***	0.283***	0.256***	0.225***	0.163***	0.516***	0.192***	0.899***	
age of 55 ^{o}	0.462***	0.199***	0.401***	0.393***	0.577***	0.241***	0.246***	0.171**	0.164***	0.549***	0.200***	0.892***	0.311***
age of 56 ^{o}	0.431***	0.207***	0.415***	0.371***	0.574***	0.228***	0.234***	0.184***	0.150***	0.535***	0.215***	0.897***	0.331***
age of 57 ^{o}	0.442***	0.134*	0.411***	0.385***	0.561***	0.242***	0.241***	0.130	0.153***	0.522***	0.211***	0.838***	0.273**
age of 58 ^{o}	0.414***	0.138*	0.370***	0.385***	0.521***	0.0289	0.266***	0.0883	0.154***	0.444***	0.170**	0.873***	0.301***
age of 59 ^{o}	0.402***	0.149**	0.341***	0.384***	0.491***	-0.0197	0.245***	0.109	0.143***	0.478***	0.136*	0.879***	0.207
age of 60 ^{o}	0.365***	0.0942	0.331***	0.327***	0.399**		0.238***	0.148*	0.133***	0.433***		0.866***	-0.0300
age of 61 ^{o}	0.256*	0.124*	0.283**	0.388***	0.416**		0.224***	0.0178	0.143***	0.190		0.842***	0.0816
age of 62 ^{o}	0.245*	0.0574	0.207	0.299*	0.415**		0.210***	-0.0613	0.124***	0.169		0.844***	-0.166
age of 63 ^{o}	0.144	0.0429	0.0261	0.241	0.344*		0.202***	-0.0389	0.120***	0.259		0.834***	-0.154
age of 64 ^{o}	0.0387	-0.165	0.00276	0.325**	0.411**		0.105	-0.106	0.0764	0.213		0.817***	0.175
SPH10	**0.0894*** **	**0.0714*** **	**0.120*** **	**0.0540** **	**0.0402* **	**0.0767*** **	**0.0848*** **	**0.0391** **	**0.0638*** **	**0.109*** **	**0.0828*** **	**0.0527*** **	**0.0531* **
Observations	534	555	632	391	540	415	647	675	336	732	405	555	209
Pseudo R^2	0.333	0.222	0.356	0.288	0.362	0.308	0.421	0.292	0.336	0.461	0.306	0.330	0.319

Table D.7: LIMITATION: Marginal effects on probability of being active: women

country code	DE	SE	NL	SP	IT	FR	DM	GR	CH	BE	CZ	PO	IR
marital status °	-0.159*	-0.112**	-0.118	-0.134	-0.0587	-0.120*	-0.0534	-0.158*	-0.00757	-0.0405	-0.0655	-0.0166	-0.242**
spouse's status °	0.0977	0.125**	0.159***	-0.0447	-0.0506	0.146**	0.0576	0.0987	-0.0264	0.0551	0.150*	0.130*	0.332***
num. of children	-0.00489	0.0178	-0.0494**	-0.0357	-0.0340	-0.0362*	-0.00472	-0.0727*	-0.0658**	-0.000548	0.0149	-0.0176	-0.0423*
lives in a city °	0.0507	0.129**	-0.0173	0.0343	-0.0393	0.0625	0.0557	0.218*	0.108	0.0596	0.0129	0.0751	-0.145
lives in a town °	-0.0649	0.0285	-0.0319	0.0318	-0.0323	-0.0761	0.0231	0.151	-0.0202	0.0387	0.0212	0.0811	-0.204*
civil employee °	0.270***	0.211***	0.262***	0.537***	0.475***	0.241***	0.211***	0.625***	0.183**	0.482***	-0.0904	-0.0922*	0.242**
self_employed °	0.343***	0.210***	0.371***	0.687***	0.439***	0.255***	0.172**	0.641***	0.341***	0.614***	-0.101	0.186*	0.247*
secondary ed. °	0.277**	-0.0811	0.121	0.267*	0.308***	0.161*	0.00866	0.0951	0.0909	0.176	0.208***	0.0437	0.218*
university ed. °	0.312**	0.127	0.201***	0.115*	0.276***	0.264**	0.121	0.205**	0.139	0.261***	0.297***	0.210*	0.269**
age of 50 °	0.341*	X	0.536***	0.409	0.627***	0.291***	X	0.258	0.267***	0.584***	0.358***	0.661***	0.367
age of 51 °	0.402***	0.158*	0.566***	0.435	0.588***	0.288***	0.374***	0.223	0.353***	0.670***	0.335***	0.524**	0.512***
age of 52 °	0.329**	X	0.541***	0.362	0.627***	0.241***	0.380***	0.159	0.356***	0.664***	0.310***	0.607***	0.483***
age of 53 °	0.466***	0.117	0.519***	0.418	0.547***	0.256***	0.341***	0.164	0.335***	0.666***	0.335***	0.584***	0.376*
age of 54 °	0.438***	0.0758	0.509***	0.299	0.507***	0.291***	0.343***	0.175	0.280***	0.649***	0.323***	0.446*	0.263
age of 55 °	0.400***	0.159*	0.480***	0.420	0.509***	0.219***	0.339***	0.140	0.309***	0.680***	0.322***	0.322	0.288
age of 56 °	0.454***	0.0646	0.406***	0.385	0.438**	0.197**	0.346***	0.199	0.323***	0.593***	0.336***	0.233	0.375*
age of 57 °	0.335**	0.105	0.368**	0.257	0.341*	0.171*	0.347***	0.0596	0.326***	0.604***	0.295***	0.197	0.409*
age of 58 °	0.368***	0.0889	0.408***	0.278	0.391*	0.117	0.327***	-0.0746	0.299***	0.529***	0.278***	0.170	0.405*
age of 59 °	0.241	0.150	0.388***	0.0662	0.218	0.127	0.321***	-0.196	0.254***	0.547***	0.190	-0.0929	0.117
age of 60 °	0.192	0.123	0.286*	-0.0710			0.307***		0.152	0.415*			0.233
age of 61 °	0.136	0.0125	0.168	0.0623			0.263***		0.201*	0.402*			0.292
age of 62 °	0.103	-0.117	0.117	-0.0481			0.228**		0.152	0.406*			0.371*
age of 63 °	-0.105	-0.228	-0.192	0.0336			0.157		0.154	0.144			-0.215
age of 64 °	-0.212	-0.376*	-0.140	-0.00660			0.0312						0.169
LIMITATION °	**-0.252*** **	**-0.503*** **	**-0.307*** **	**-0.129***	**-0.110**	**-0.258*** **	**-0.540*** **	**-0.185***	**-0.284** **	**-0.269*** **	**-0.559*** **	**-0.267*** **	**-0.262** **
Observations	593	610	785	471	469	444	663	540	374	752	426	540	262
Pseudo R^2	0.234	0.316	0.270	0.307	0.238	0.235	0.369	0.336	0.222	0.312	0.346	0.282	0.270

Table D.9: HEALTH-US: Marginal effects on probability of being active: women

country code	**DE**	**SE**	**NL**	**SP**	**IT**	**FR**	**DM**	**GR**	**CH**	**BE**	**CZ**	**PO**	**IR**
marital status ^{o}	-0.139*	-0.0640	-0.126*	-0.125	-0.0542	-0.129*	-0.0254	-0.154*	0.0148	-0.0180	-0.0503	-0.0421	-0.229*
spouse's status ^{o}	0.0990	0.105**	0.180***	-0.0615	-0.0531	0.142**	0.0928*	0.109	-0.0447	0.0429	0.149**	0.165**	0.323***
num. of children	0.000467	0.00555	-0.0576**	-0.0352	-0.0339	-0.0368*	-0.0107	-0.0703*	-0.0586**	-0.00592	-0.0112	-0.0162	-0.0452*
lives in a city ^{o}	0.0345	0.102*	-0.00405	0.0502	-0.0316	0.0668	0.102	0.238**	0.128	0.0378	-0.0584	0.0672	-0.151
lives in a town ^{o}	-0.0313	0.0184	-0.0569	0.0520	-0.0336	-0.0775	0.0750	0.174	-0.0205	0.0189	-0.0442	0.0625	-0.227*
civil employee ^{o}	0.256***	0.200***	0.240***	0.538***	0.466***	0.232***	0.192***	0.620***	0.184***	0.495***	-0.124*	-0.0986*	0.240**
self_employed ^{o}	0.333***	0.220***	0.340***	0.685***	0.437***	0.259***	0.102	0.642***	0.340***	0.615***	-0.129	0.139	0.247*
secondary ed. ^{o}	0.262*	-0.0355	0.0923	0.277*	0.308***	0.148*	-0.00902	0.114	0.0819	0.223	0.173**	0.0220	0.202*
university ed. ^{o}	0.314**	0.134	0.190***	0.111*	0.276***	0.252**	0.0976	0.219***	0.145	0.276***	0.286***	0.197*	0.249**
age of 50 ^{o}	0.268		0.518***	0.405	0.628***	0.289***		0.256	0.275***	0.581***	0.332***	0.696***	0.375
age of 51 ^{o}	0.394***	0.162*	0.545***	0.401	0.585***	0.286***	0.369***	0.244	0.355***	0.666***	0.331***	0.513**	0.498***
age of 52 ^{o}	0.330**		0.536***	0.364	0.634***	0.238***	0.371***	0.167	0.359***	0.665***	0.289***	0.599***	0.454***
age of 53 ^{o}	0.454***	0.161*	0.516***	0.414	0.546***	0.262***	0.344***	0.193	0.340***	0.660***	0.315***	0.600***	0.347
age of 54 ^{o}	0.423***	0.0981	0.497***	0.293	0.511***	0.290***	0.340***	0.199	0.290***	0.635***	0.331***	0.471*	0.232
age of 55 ^{o}	0.375***	0.180**	0.454***	0.412	0.514***	0.226***	0.344***	0.173	0.315***	0.672***	0.325***	0.346	0.255
age of 56 ^{o}	0.437***	0.0971	0.398***	0.363	0.442**	0.205***	0.345***	0.227	0.337***	0.587***	0.317***	0.285	0.358*
age of 57 ^{o}	0.318*	0.0946	0.329*	0.233	0.343*	0.179*	0.351***	0.0779	0.335***	0.606***	0.298***	0.198	0.392*
age of 58 ^{o}	0.338**	0.130	0.404***	0.292	0.395*	0.133	0.330***	-0.0465	0.309***	0.548***	0.264***	0.163	0.405*
age of 59 ^{o}	0.183	0.153*	0.361**	0.0616	0.228	0.135	0.314***	-0.184	0.261***	0.559***	0.156	-0.110	0.0640
age of 60 ^{o}	0.159	0.133	0.276*	-0.0848			0.302***		0.171	0.428*			0.252
age of 61 ^{o}	0.0909	0.0119	0.170	0.0369			0.270***		0.230*	0.407*			0.257
age of 62 ^{o}	0.0994	-0.0940	0.116	-0.0498			0.232**		0.180	0.430*			0.383*
age of 63 ^{o}	-0.152	-0.144	-0.218	0.0311			0.150		0.175	0.201			-0.165
age of 64 ^{o}	-0.244	-0.322	-0.0857	-0.0191			0.0818						0.172
SPH10	**-0.0847*** **	**-0.134*** **	**-0.135*** **	**-0.0696** **	**-0.0502* **	**-0.0837*** **	**-0.141*** **	**-0.0344**	**-0.0743** **	**-0.0930*** **	**-0.196*** **	**-0.112*** **	**-0.0649**
Observations	594	611	786	471	469	444	664	540	375	752	426	541	262
Pseudo R^2	0.226	0.251	0.267	0.312	0.241	0.231	0.294	0.333	0.218	0.300	0.258	0.256	0.258

Table D.11: HEALTH10: Marginal effects on probability of being active: women

country code	DE	SE	NL	SP	IT	FR	DM	GR	CH	BE	CZ	PO	IR
marital status °	-0.151*	-0.0947*	-0.130*	-0.104	-0.0537	-0.121*	-0.0217	-0.156*	0.00859	-0.0184	-0.0703	-0.0416	-0.261**
spouse's status °	0.104*	0.127**	0.170***	-0.0706	-0.0517	0.144**	0.0802	0.104	-0.0349	0.0424	0.162**	0.182**	0.335***
num. of children	-0.00557	0.0167	-0.0517**	-0.0357	-0.0346	-0.0340	-0.0143	-0.0694*	-0.0597**	-0.00230	-0.0113	-0.0140	-0.0422*
lives in a city °	0.0324	0.0946	0.00300	0.0499	-0.0334	0.0754	0.102	0.244**	0.116	0.0498	-0.0693	0.0692	-0.162
lives in a town °	-0.0346	-0.00317	-0.0366	0.0480	-0.0309	-0.0582	0.0690	0.173	-0.00671	0.0237	-0.00512	0.0511	-0.221*
civil employee °	0.266***	0.203***	0.259***	0.557***	0.468***	0.230***	0.190***	0.621***	0.196***	0.489***	-0.148**	-0.0879*	0.264***
self_employed °	0.321***	0.213***	0.368***	0.687***	0.436***	0.259***	0.120	0.648***	0.337***	0.622***	-0.0988	0.136	0.251*
secondary ed. °	0.255*	-0.0516	0.134	0.252*	0.303***	0.147*	0.0114	0.116	0.0959	0.210	0.200***	0.0226	0.223*
university ed. °	0.306**	0.114	0.191***	0.103	0.271***	0.238**	0.108	0.224***	0.169*	0.254***	0.291***	0.177	0.285**
age of 50 °	0.274	X	0.516***	0.417	0.629***	0.291***	X	0.256	0.272***	0.573***	0.335***	0.681***	0.358
age of 51 °	0.401***	0.184**	0.540***	0.421	0.577***	0.293***	0.371***	0.248	0.352***	0.667***	0.342***	0.510**	0.498***
age of 52 °	0.344**	X	0.531***	0.353	0.631***	0.247***	0.369***	0.172	0.361***	0.668***	0.310***	0.592***	0.452**
age of 53 °	0.466***	0.203***	0.515***	0.422	0.543***	0.261***	0.344***	0.202	0.340***	0.671***	0.327***	0.574***	0.350
age of 54 °	0.438***	0.160*	0.483***	0.330	0.504***	0.296***	0.338***	0.198	0.288***	0.646***	0.326***	0.464*	0.234
age of 55 °	0.391***	0.174*	0.460***	0.423	0.501***	0.227***	0.342***	0.169	0.313***	0.674***	0.333***	0.358	0.280
age of 56 °	0.445***	0.133	0.388***	0.371	0.436**	0.202**	0.341***	0.230	0.335***	0.587***	0.319***	0.281	0.398*
age of 57 °	0.332**	0.142	0.313*	0.277	0.338	0.193**	0.348***	0.0774	0.334***	0.610***	0.291***	0.204	0.384*
age of 58 °	0.371***	0.161*	0.381***	0.280	0.390*	0.119	0.326***	-0.0515	0.305***	0.551***	0.263***	0.146	0.405*
age of 59 °	0.225	0.171*	0.349**	0.0567	0.219	0.141	0.312***	-0.186	0.255***	0.555***	0.157	-0.0941	0.0518
age of 60 °	0.186	0.161*	0.270*	-0.0768			0.295***		0.164	0.448**			0.249
age of 61 °	0.122	0.0622	0.147	0.0486			0.250***		0.222*	0.418*			0.260
age of 62 °	0.111	-0.0177	0.0709	-0.0444			0.202*		0.160	0.448**			0.380*
age of 63 °	-0.112	-0.0689	-0.213	0.0590			0.121		0.174	0.174			-0.170
age of 64 °	-0.205	-0.254	-0.115	-0.00273			0.0410						0.154
SPH10	**0.0607*** **	**0.104*** **	**0.110*** **	**0.0572*** **	**0.0258**	**0.0504** **	**0.0976*** **	**0.0260**	**0.0282**	**0.0881*** **	**0.0894*** **	**0.0673*** **	**0.0623** **
Observations	594	611	785	469	469	442	663	540	374	752	425	540	261
Pseudo R^2	0.234	0.267	0.266	0.321	0.237	0.222	0.293	0.334	0.215	0.308	0.247	0.263	0.266

Table D.13: Chow test of Hypothesis 2 using LIMITATION

country code	**DE**	**SE**	**NL**	**SP**	**IT**	**FR**	**DM**	**GR**	**CH**	**BE**	**CZ**	**PO**	**IR**
LIMITATION °	-0.352***	-0.446***	-0.377***	-0.377***	-0.268***	-0.317***	-0.449***	-0.429***	-0.479***	-0.397***	-0.511***	-0.315***	-0.474***
female °	-0.176***	-0.0243	-0.225***	-0.365***	-0.283***	-0.0405	-0.0709*	-0.454***	-0.230***	-0.207***	-0.0809	-0.183***	-0.237***
LIMITATION x female	0.126	-0.0173	0.0597	**0.232***	0.185	0.0588	-0.0821	0.158	**0.152****	0.119	-0.0215	0.0258	0.178
Observations	1133	1189	1421	866	977	855	1322	1194	710	1484	831	1046	487
Pseudo R^2	0.266	0.274	0.303	0.330	0.295	0.251	0.382	0.373	0.257	0.392	0.337	0.311	0.263

LIMITATION x female is an interaction term. Coefficients for control variables were dropped for the sake of brevity.

Table D.15: Chow test of Hypothesis 2 using HEALTH-US

country code	**DE**	**SE**	**NL**	**SP**	**IT**	**FR**	**DM**	**GR**	**CH**	**BE**	**CZ**	**PO**	**IR**
HEALTH-US	-0.177***	-0.0810***	-0.108***	-0.104***	-0.0358	-0.0824**	-0.124***	-0.0668*	-0.0977***	-0.129***	-0.185***	-0.0989***	-0.121**
female °	-0.418***	0.0726	-0.159	-0.342**	-0.214	-0.0536	-0.111	-0.467***	-0.286***	-0.252**	-0.147	-0.107	-0.306**
HEALTH-US x female	**0.0970****	-0.0408	-0.0221	0.0143	-0.0196	0.0103	-0.00584	0.0177	0.0430	0.0280	0.0178	-0.0173	0.0462
Observations	1133	1189	1421	866	977	855	1322	1194	710	1484	831	1046	487
Pseudo R^2	0.266	0.274	0.303	0.330	0.295	0.251	0.382	0.373	0.257	0.392	0.337	0.311	0.263

HEALTH-US x female is an interaction term. Coefficients for control variables were dropped for the sake of brevity.

Table D.17: Chow test of Hypothesis 2 using HEALTH10

country code	**DE**	**SE**	**NL**	**SP**	**IT**	**FR**	**DM**	**GR**	**CH**	**BE**	**CZ**	**PO**	**IR**
HEALTH10	0.0875***	0.0784***	0.122***	0.0597***	0.0213	0.0751***	0.0888***	0.0437*	0.0874***	0.0949***	0.0959***	0.0587***	0.0557*
female °	0.0822	-0.143	-0.115	-0.408*	-0.323	0.175	-0.144	-0.346	0.332	-0.175	0.0466	-0.255*	-0.169
HEALTH10 x female	-0.0313	0.0133	-0.0147	0.0150	0.00721	-0.0273	0.00222	-0.0122	**-0.0663****	-0.00119	-0.0196	0.0127	-0.00565
Observations	1133	1189	1421	866	977	855	1322	1194	710	1484	831	1046	487
Pseudo R^2	0.266	0.274	0.303	0.330	0.295	0.251	0.382	0.373	0.257	0.392	0.337	0.311	0.263

HEALTH10 x female is an interaction term. Coefficients for control variables were dropped for the sake of brevity.

Table D.19: Chow test of Hypothesis 2 using principal components of health

country code	DE	SE	NL	SP	IT	FR	DM	GR	CH	BE	CZ	PO	IR
comp1	-0.368***	-0.240***	-0.382***	-0.517***	-0.251**	-0.368***	-0.495***	-0.285**	-0.439***	-0.365***	-0.730***	-0.303***	-0.310***
comp2	0.00824	-0.00408	-0.00205	-0.0807*	-0.0328	-0.0358	-0.0491**	-0.0273	-0.0212	0.00894	-0.107**	-0.0267	0.0380
comp3	-0.0116	-0.00682	-0.000523	-0.0259	-0.0261	-0.0311	-0.0202	-0.00996	0.0344	0.0234	-0.0329	-0.00193	-0.00243
comp4	-0.0367*	0.00505	-0.00592	0.0319	0.00654	0.0179	-0.0169	0.0135	-0.0314	-0.0112	-0.0139	-0.0275	-0.0214
comp5	-0.0395*	-0.0149	0.0108	-0.0183	-0.0312	-0.0432*	0.0117	-0.0320	-0.00495	-0.0540**	-0.0386	-0.0246	0.0100
female °	-0.109	0.0780	-0.289**	-0.347	-0.489***	-0.330**	-0.183	-0.547***	-0.518***	-0.158	-0.518**	-0.174	-0.246
female x comp1	-0.00347	-0.0602	0.0828	0.0356	0.170	**0.241****	0.0720	0.134	**0.307****	0.0111	**0.392****	0.0212	0.0635
female x comp2	-0.0782**	0.00539	0.0142	-0.00220	0.0478	0.0476	0.0224	0.0106	0.0111	-0.0495*	0.100**	0.0239	-0.0620
female x comp3	0.0217	0.0145	0.00302	-0.0261	0.000282	0.0336	0.0294	0.0270	-0.0434	-0.0184	0.0452	-0.0253	-0.00699
female x comp4	0.0488*	-0.00161	-0.00259	-0.0326	-0.0398	-0.0179	0.0120	0.00372	0.0132	0.0185	-0.00337	0.00717	-0.0342
female x comp5	0.0588*	0.0106	-0.00190	0.00843	-0.00674	0.0225	-0.0273	0.0163	-0.0106	0.0308	0.0550*	0.00627	0.0148
Observations	1130	1191	1421	864	978	854	1323	1196	712	1482	830	1047	487
Pseudo R^2	0.288	0.226	0.307	0.344	0.304	0.269	0.380	0.365	0.272	0.394	0.289	0.298	0.261

comp1 – comp5 indicate scores for somponents 1 to 5; female x comp is an interaction term

Appendix E

Content of Enclosed DVD

There is a DVD enclosed to this thesis which contains Stata source codes and this thesis in a .pdf file.

- Folder 1: Source codes
- Folder 2: This thesis